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Report No. DPS/TW-403/5

AUTOMOTIVE DIVISION

REPORT ON

EVALUATION OF ONE T113 AND ONE T117

UNIVERSAL CARRIER HULL AGAINST

COMBAT ATTACK (U)

FC

Fifth Report On Ordnance Project TW-403

(D. A. Project No. 545-07-032)  
(AD-1271)

W. B. FRYE

JULY 1959



Aberdeen Proving Ground  
Maryland

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DEVELOPMENT AND PROOF SERVICES  
ABERDEEN PROVING GROUND  
MARYLAND

AUTHORITY: ORDMC-REM.1  
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EVALUATION OF ONE T113 AND ONE T117  
UNIVERSAL CARRIER HULL AGAINST  
COMBAT ATTACK (U)

Fifth Report on Ordnance Project TW-403

Dates of Test: September 1957 to November 1958

ABSTRACT (C)

One T113 hull composed of aluminum armor and one T117 hull fabricated with rolled homogeneous steel armor were subjected to ballistic tests consisting of resistance to penetration by high-explosive shell fragments, ballistic shock tests of the welded joints, resistance to penetration of the virgin armor with small-arms fire, and resistance-to-splash tests from impacting small-arms fire around the various door and hatch openings. Satisfactory comparisons between the T113 and T117 vehicle hulls were obtained for the test conditions outlined above. It is recommended that consideration be given to increasing the armor thickness of the T113 hull within allowable weight limitations in order to provide a level of protection more nearly equal to that afforded by the T117 hull against high-explosive shell fragments and small-arms fire.

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MEMORANDUM REPORT

(The Annex is on file in the Technical Library, APG.  
for reference purposes. Copies of the Annex may be  
furnished to recipients of this report upon request.)

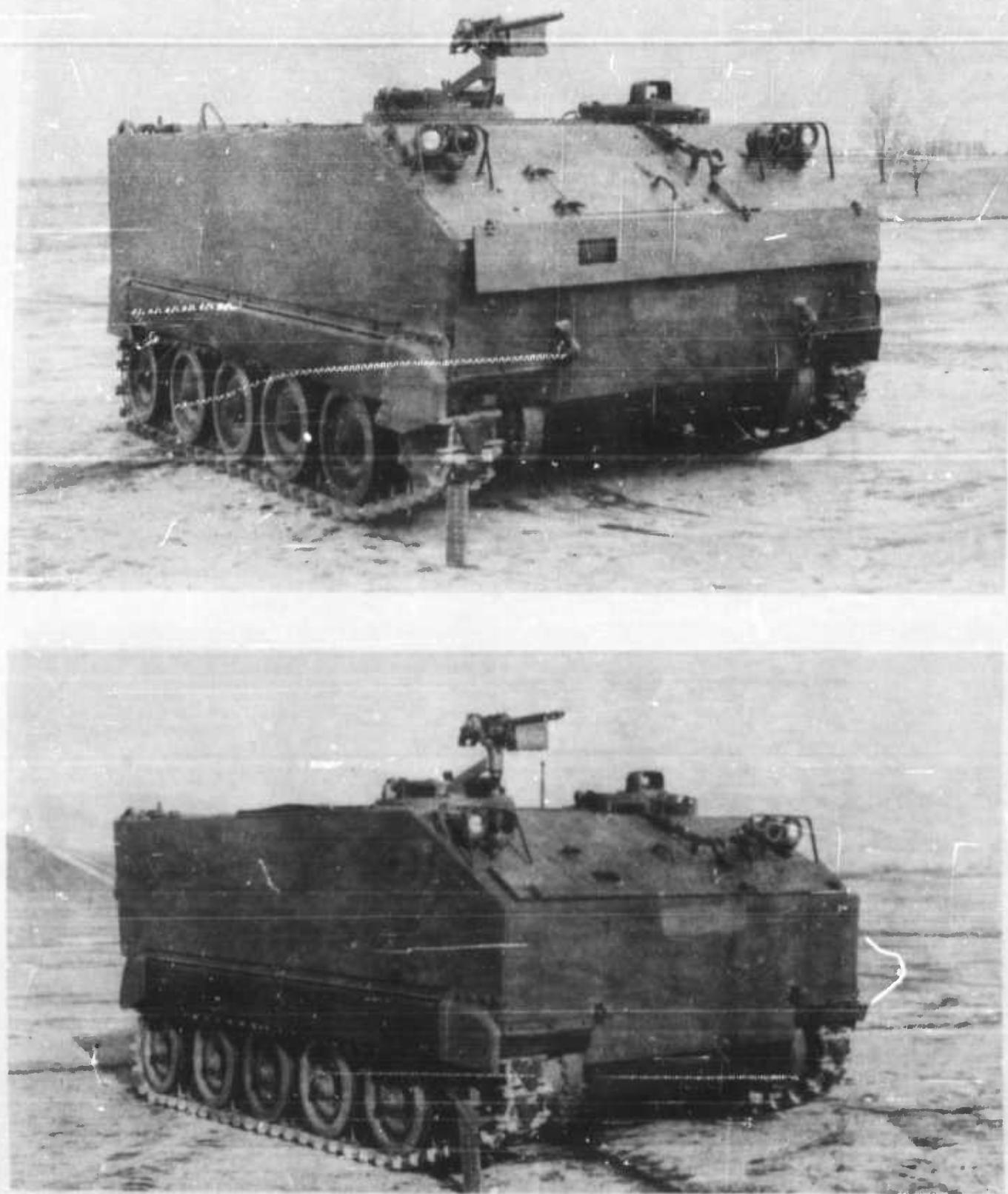


Figure 1: Three-quarter Right Front Views of T113 (TOP) and T117 (BOTTOM) Universal Carriers.

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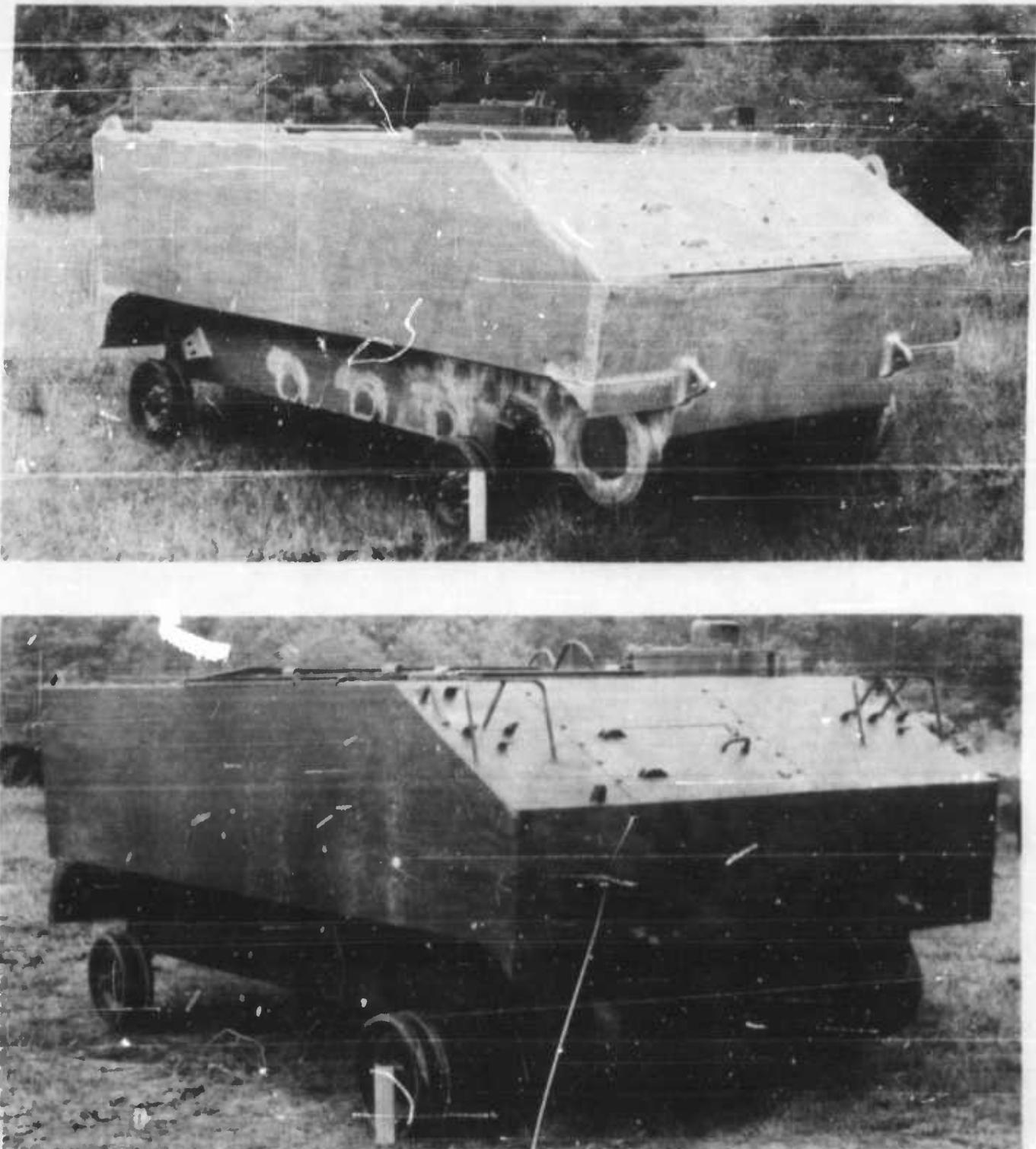


Figure 2: General Views of T113 Hull (TOP) and T117 Hull (BOTTOM) as Submitted for Test.

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## 1. (C) INTRODUCTION

The T113 and T117 universal carriers (Fig. 1) are two of the newest lightly armored, highly mobile, armored infantry vehicles undergoing tests by the Ordnance Corps. The increasing emphasis on air transportability and air drops in modern tactics places a severe weight limitation on any vehicle designed for universal use. In an effort to save weight, the T113 was fabricated from aluminum armor.

The selection of aluminum as a basic armor material for the T113 is the result of development programs in vehicles and materials that have taken place in the past ten years. The very philosophy behind the T113 suggests a new approach in Ordnance development. No longer will it be necessary to develop each vehicle for a specific purpose, but rather the development will be for the "universal chassis" upon which can be placed the appropriate kits for the application required. Consequently, production can be geared to the needs of the field forces without major revisions in design and tooling.

## 2. (C) DESCRIPTION OF MATERIEL

The one T113 and one T117 hull submitted for test were received with one road wheel installed at each corner of the hull and all interior and exterior mounting brackets welded in place (Fig. 2).

The T113 vehicle was fabricated mainly from 1-1/4 inch thick aluminum and the upper hull side plates, roof plate and sloped upper and lower nose plates were all of this thickness. The vertical nose plate was 1-3/4 inches thick and the main floor plate was 3/8 inch thick. The lower hull side plates were 3/4 inch thick. The aluminum armor alloy 5083 (H115) was used in fabricating the T113 hull by the MIG welding process with 5356 aluminum wire.

The T113 was designed with two different types of welded joints employed between the upper hull side plate and the upper glacis plate and hull roof plate. An interlocking or "dove tail" incomplete-weld-penetration joint was used on the right side of the hull (Fig. 3). In a joint of this type each plate of the joint is alternately recessed or notched to a predetermined distance so that when the two plates are brought together and joined by a continuous weld pass a true interlocking design is achieved.

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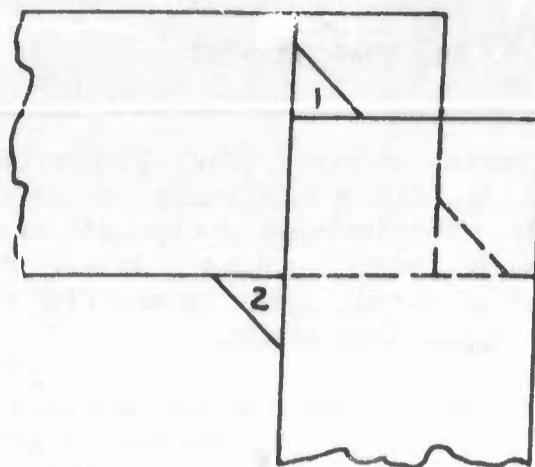


Fig 3  
Figure 3: Cross Sectional View of a Typical Interlocking Joint.

On the left side of the hull a rebated-type incomplete-weld-penetration joint was used.

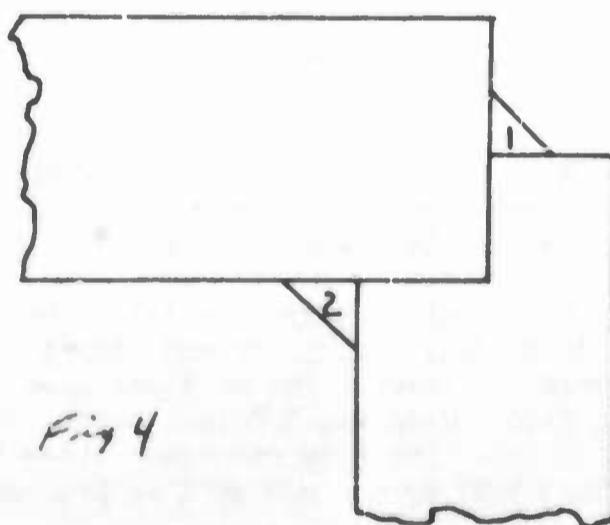


Fig 4  
Figure 4: Cross Sectional View of a Typical Rebated Joint.

In the rebated-type welded joint the edge of the vertical plate was recessed to allow the horizontal plate to set down one-half of its thickness on the edge of the vertical plate. The remaining joints of the T113 were fabricated with the standard incomplete-weld-penetration procedure, except for one. This exception was the joint between the main roof plate and the formed upper glacis plate containing the driver's hatch; these plates were joined by a complete-penetration joint.

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The T117 vehicle was fabricated from a rolled homogeneous steel armor of a modified hardness. The main armor of this hull was of 1/2-inch thickness except for a 5/8-inch-thick vertical front nose plate, a 3/16-inch-thick main floor plate and a 3/8-inch-thick lower hull side plate. This hull was designed with all conventional incomplete-weld-penetration joints (Fig. 5).

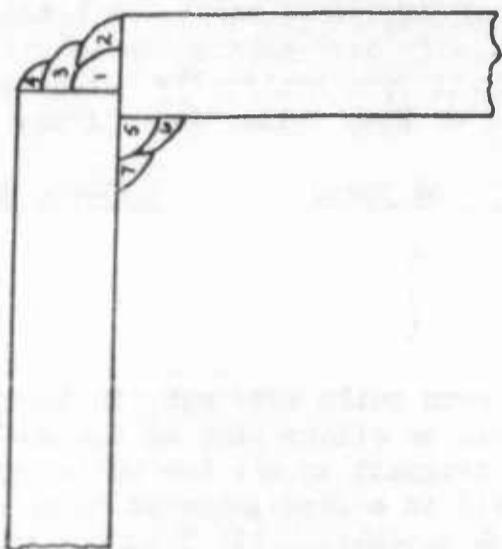


Figure 5: Cross Sectional View of Conventional Incomplete-Weld-Penetration Joint.

## 3. (C) DETAILS OF TEST

### 3.1 Procedure

The testing program was divided into four phases, as follows:

Phase I - Resistance to penetration by shell fragments from 105-mm shell, HE, M1 at distances of 90, 50 and 20 feet against roof and side plates.

Phase II - Ballistic shock test of the welded joints using the 37-mm shell, HE, M54 and the 57-mm proof projectile, M1001.

Phase III - Resistance to penetration of the virgin armor with small arms.

Phase IV - Resistance to bullet splash from impacting small-arms fire around doors and hatches.

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Before any ballistic testing was accomplished each hull was weighed. A weight of 7,725 lb for the T113 and 9,500 lb for the T117 was recorded.

### 3.2 Results

3.2.1 Phase I. This phase consisted of a test of resistance to penetration by fragments from high-explosive shell. A total of twelve 105-mm high-explosive shell was statically detonated at three distances from the hull roof plates and twelve shell were statically detonated at three distances from the hull side plates of both hulls, as follows:

| <u>No. of Shell</u> | <u>Distance from Shell, feet</u> |
|---------------------|----------------------------------|
| 8                   | 90                               |
| 3                   | 50                               |
| 1                   | 20                               |

In conducting the tests both hulls were set, in turn, at the distances listed above with one hull on either side of the shell to be detonated. In order to catch the main fragment spray, the hulls were positioned 7° back from the nose of the shell in a line measured perpendicular to the side wall of the shell. After each detonation all fragment impacts were counted, marked, and any damage resulting from these impacts was recorded.

As a result of the eight shell detonated at the 90-foot distance from the 1-1/4 inch hull roof plates of the T113, three complete penetrations were obtained. No complete penetrations occurred on the T117 from this attack distance.

From the eight shell detonated in the test of the hull side plates at the 90-foot distance, one complete penetration occurred on the 3/4-inch-thick lower hull side plate of the T113 hull and none occurred for the T117.

From the three shell detonated in the test of the hull roof plates at the 50-foot distance, three complete penetrations occurred on the T113. Two of these complete penetrations occurred on the grilles and one on the 1-1/4-inch thick roof. On the T117, two complete penetrations occurred. One fragment penetrated the engine grille and the other penetrated a steel plate covering the commander's cupola opening. This cover plate was composed of steel armor of the same quality used in the fabrication of the T117 vehicle.

From the three shell detonated in the test of the hull side plate at the 50-foot distance, two complete penetrations occurred on the 3/4-inch-thick lower hull side plate of the T113 hull. Two complete penetrations also occurred on the 3/8-inch-thick lower hull side plate of the T117.

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From the one shell detonated at the 20-foot distance against the hull roof plates, three complete penetrations occurred in the 1-1/4-inch-thick roof plate of the T113. None occurred on the T117.

From the one shell detonated at the 20-foot distance against the hull side plates, two complete penetrations occurred on the 1-1/4-inch-thick upper hull side plate of the T113 hull and none occurred on the T117.

The results of the test against shell fragments should be considered only as a general indication of the protection provided. Variables inherent in such a test (which include fragment size, fragment velocity, fragment orientation at impact, and number of fragment impacts) prevent an accurate evaluation unless a much greater number of shell are detonated and the target is of much greater dimensions.

In studying the results it should also be remembered that the 1-1/4 inch aluminum upper side armor of the T113 which weighs approximately 17.3 pounds per square foot while the 1/2-inch steel upper side armor of the T117 vehicle weighs approximately 20.4 pounds per square foot.

The detailed round-by-round data obtained in Phase I are contained in Appendix B.

3.2.2 Phase II. The second phase of testing consisted of a ballistic shock test of the welded joints of both vehicles. The hulls were fabricated with three different types of welded joints. An interlocking or "dove tail" incomplete-weld-penetration joint was used on the right side of the T113 at the joint between the hull roof plate and upper hull side plate and at the joint between the upper glacis plate and upper hull side plate. The corresponding joints on the left side were fabricated with a rebated-type incomplete-weld-penetration procedure. In the rebated-type welded joint, the edge of the vertical plate is recessed to allow the horizontal plate to set down one half of its thickness on the edge of the vertical plate. The remaining joints of the T113 were fabricated with the standard incomplete-weld-penetration procedure, except for one. The exception was the joint between the main roof plate and the formed upper glacis plate containing the driver's hatch. These plates were joined by a complete-penetration weld. The T117 vehicle was fabricated with all conventional incomplete-penetration welds.

A comparison of the three types of welded joints presented for test in these two hulls shows very little difference in performance. The rebated-type joint on the left side of the T113 hull offered the lowest resistance to shock-producing impacts. An average weld-area crack of 11-7/8 inches occurred in the rebated-type weld joint between the upper hull side plate and main roof plate. At the rebated-type joint between the upper hull side plate and upper glacis plate an average weld-area crack of 12 inches occurred. On the right side of the T113 incorporating the interlocking type joints, an average weld area crack of 7-5/8 inches occurred at the junction of the roof plate and upper hull side plate with the interlocks tested in the shear condition. In this same area with the interlocks tested in the compression

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condition, no weld-area cracking occurred. At the joint between the upper hull side plate and upper glacis plate an average weld-crack of 7-3/4 inches developed with the interlocks tested in the shear condition. In this same area with the interlocks tested in the compression condition, an average weld area crack of 1-1/2 inches was noted. The fact should be borne in mind that when an interlocking joint develops a weld-area crack in one interlock the nature of this joint design prevents the crack from being propagated by repeated impacts in adjacent areas. In the incomplete-penetration welds on the T117 hull, an average weld-area crack of 1-5/8 inches developed at the joint between the upper hull side plate and roof plate. At the joint between the upper hull side plate and upper glacis plate an average weld-area crack of 8 inches occurred.

Immediately following the shock testing of the welded joints, the virgin armor of the upper hull side plates of both hulls was also subjected to a ballistic-shock test. This test was conducted to determine the critical rupture velocity level of the virgin armor when attacked with the 37-mm, HE, M54 shell.

A rupture of the 1-1/4 inch-thick aluminum armor of the T113 vehicle occurred at a striking velocity of 2498 fps. The plate crack was 4-1/4 inches in length. A large bulge with no cracking occurred at a striking velocity of 2471 fps. On the 1/2-inch-thick steel armor of the T117, a one-inch plate crack was developed at a striking velocity of 2832 fps. However, the tack weld of a small bracket that was displaced by this impact may have somewhat influenced the development of this crack. In order to investigate this possibility, the T117 upper hull side plate was subjected to two impacts at a striking velocity of 2844 fps each, which was the maximum velocity that could be obtained with the weapon and projectile used in this test. No cracks occurred on either impact.

The detailed round-by-round data obtained in Phase II are contained in Appendix C.

**3.2.3 Phase III.** The third phase of testing the T113 and T117 universal carrier hulls consisted of resistance to penetration by small arms fire using armor-piercing, ball and fragment-simulator projectiles. The results are summarized in Table I.

The upper hull side plates and personnel access door in the ramps of each vehicle along with the vertical nose plate of the T113 hull were subjected to attack by the three types of ammunition from various obliquities. No effort was made to test the vertical nose plate of the T117 hull because the thickness of this plate on the test vehicle was greater than planned for a production T117 hull.

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Table I. Summary of Resistance-to-Penetration Tests of T113 and T117 Hulls

| Caliber                              | Condition of Attack | T113                            |                       | T117                            |                       |
|--------------------------------------|---------------------|---------------------------------|-----------------------|---------------------------------|-----------------------|
|                                      |                     | Protection Ballistic Limit, fps | Equivalent Range, yds | Protection Ballistic Limit, fps | Equivalent Range, yds |
| <u>Upper Hull Side Plate</u>         |                     |                                 |                       |                                 |                       |
| .30 AP                               | 0°                  | 2051                            | 310                   | 2205                            | 240                   |
| .50 AP                               | 0°                  | 1442                            | 1300                  | 1321                            | 1380                  |
| .50 Ball                             | 0°                  | 1506                            | 1190                  | 2486                            | 340                   |
| .30 AP                               | 45°                 | 3152                            | Point Blank           | No BL(P) obtained               | Point Blank           |
|                                      |                     |                                 | High PP(P) = 3444     |                                 |                       |
| .50 AP                               | 45°                 | 2162                            | 575                   | 2805                            | 20                    |
| 20-mm Frag.Sim.                      | 0°                  | 1919                            | -Not Tested-          |                                 |                       |
| 20-mm Frag.Sim.                      | 45°                 | 2863                            | -                     | No BL(P) obtained               | -                     |
|                                      |                     |                                 | High PP(P) = 2873     |                                 |                       |
| <u>Front Nose Plate</u>              |                     |                                 |                       |                                 |                       |
| .30 AP                               | Direct Front        | 2445                            | 150                   | Not tested due to incorrect     |                       |
| .50 AP                               | Direct Front        | 1756                            | 920                   | thickness of nose plate on      |                       |
| .50 Ball                             | Direct Front        | 1823                            | 975                   | test hull.                      |                       |
| .50 AP                               | 30° Flank           | 2109                            | 620                   |                                 |                       |
| .50 Ball                             | 30° Flank           | 2257                            | 475                   |                                 |                       |
| .50 AP                               | 60° Flank           | No BL(P) obtained               | Point Blank           |                                 |                       |
|                                      |                     | High PP(P) = 2846               |                       |                                 |                       |
| <u>Personnel Access Door in Ramp</u> |                     |                                 |                       |                                 |                       |
| .50 Frag.Sim.                        | 0°                  | No BL(P) obtained               |                       | No BL(P) obtained               |                       |
|                                      |                     | High PP(P) = 2891               |                       | High PP(P) = 2909               |                       |
| .50 Frag.Sim.                        | 45°                 | No BL(P) obtained               |                       | Not tested.                     |                       |
|                                      |                     | High PP(P) = 2580               |                       |                                 |                       |
| 20-mm Frag.Sim.                      | 45°                 | 2166                            |                       | 2312                            |                       |

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In nearly all conditions of attack where comparisons were possible, the heavier steel armor of the T117 was somewhat superior to the aluminum armor of the T113. In one instance, however, the caliber .50 armor-piercing projectile at 0° obliquity against the upper hull side plate of the T113 gave a ballistic limit of 1442 fps while a ballistic limit of 1321 fps was obtained for the upper hull side plate of the T117 hull.

The detailed round-by-round data obtained in Phase III are contained in Appendix D.

3.2.4 Phase IV. The final phase of testing on the T113 and T117 hulls consisted of a bullet-splash test around various openings on the vehicles. The openings around the cupola, doors and hatches were impacted with caliber .30 and .50 ball projectiles to ascertain if fragments from these impacts could enter the vehicle and cause injury to the crew or vehicle components.

Table II summarizes the results of the bullet-splash test.

A study of Table II shows that under no attack condition tested with either the caliber .30 or .50 ball ammunition was any evidence encountered that bullet splash was entering the vehicle hulls. It will be noted that some complete penetrations were obtained.

The detailed round-by-round data obtained in Phase IV are contained in Appendix E.

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Table II. Splash Phase, T113 and T117 Universal Carrier, Hulls,  
Caliber .30 and Caliber .50 Ball M2  
Service Ammunition

Area Tested: T113 Engine Inspection Door

| <u>Projectile</u> | <u>No. of Impacts</u> | <u>Condition of Attack</u> | <u>Bullet Splash</u>      |
|-------------------|-----------------------|----------------------------|---------------------------|
| Cal .30 Ball M2   | 4                     | 45° obliquity              | None                      |
| Cal .50 Ball M2   | 4                     | 45° obliquity              | None                      |
| Cal .30 Ball M2   | 3                     | 0° obliquity               | None                      |
| Cal .50 Ball M2   | 2                     | 0° obliquity               | Two complete penetrations |

Area Tested: T113 Engine Access Door

|                 |   |               |      |
|-----------------|---|---------------|------|
| Cal .30 Ball M2 | 3 | 45° obliquity | None |
| Cal .50 Ball M2 | 3 | 45° obliquity | None |

Area Tested: T113 Cargo Hatch

|                 |   |              |                            |
|-----------------|---|--------------|----------------------------|
| Cal .30 Ball M2 | 5 | 0° obliquity | Five complete penetrations |
|-----------------|---|--------------|----------------------------|

Area Tested: T113 Comd'r Cupola

|                 |   |               |  |
|-----------------|---|---------------|--|
| Cal .30 Ball M2 | 5 | 15° obliquity | None                                     |
| Cal .30 Ball M2 | 4 | 30° obliquity | None                                     |
| Cal .30 Ball M2 | 3 | 45° obliquity | None                                     |
| Cal .30 Ball M2 | 1 | 0° obliquity  | Vel, fpe Four complete 1970 penetrations |

These four rounds were fired at reduced velocities.

Area Tested: T117 Personnel Access Door

|                 |   |                     |                           |
|-----------------|---|---------------------|---------------------------|
| Cal .30 Ball M2 | 5 | Direct Rear         | None                      |
| Cal .50 Ball M2 | 2 | Direct Rear         | Two complete penetrations |
| Cal .30 Ball M2 | 4 | Flank 45° obliquity | None                      |
| Cal .50 Ball M2 | 4 | Flank 45° obliquity | None                      |

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### 4. (C) CONCLUSIONS

Based on the results of this test it is concluded that:

- a. The T113 hull provides less protection than the T117 hull against high-explosive shell fragments. Variables such as fragment size, fragment velocity, fragment orientation at impact, and number of fragment impacts greatly influence the results and prevent a quantitative comparison.
- b. The resistance to shock of the three types of welded joints used in fabricating the T113 and T117 hull was acceptable.
- c. The aluminum armor of the T113 hull ruptured against the impact of the 37-mm, HE, M54 shell at a striking velocity level significantly lower than can be withstood by the steel armor of the T117 hull.
- d. The aluminum armor of the T113 hull gave a lower resistance to penetration against all comparable conditions of small-arms fire than did the steel armor of the T117 vehicle, except for the upper side plate against caliber .50 AP at 0° obliquity.
- e. The ventilating grilles on the universal carriers were found to have poor structural strength, as indicated by extreme deformation and the breaking of louver bars under high-explosive shell fragment impact.
- f. The areas subjected to test for resistance to bullet splash passage gave satisfactory protection against this type of attack.

### 5. (C) RECOMMENDATIONS

It is recommended that:

- a. Consideration be given to increasing the armor thicknesses of the T113 hull within allowable weight limitations in order to provide a level of protection more nearly equal to that afforded by the T117 hull against high-explosive shell fragments and small-arms fire.
- b. The three types of welded joints used in fabricating the T113 and T117 hulls be accepted as satisfactory for use in fabricating light-weight combat vehicles of this type.
- c. An effort be made to relocate the fuel cells in both vehicles from the rear of the left sponson to a position less vulnerable to small-arms and shell-fragment attack.

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d. The ventilating grilles on the universal carrier hulls be redesigned to provide improved structural strength.

SUBMITTED:

*Wm. B. Frye*

WM. B. FRYE  
Test Director

REVIEWED:

*W.M.C. Pless*

WM. C. PLESS  
Chief, Armor Branch

*C.D. Montgomery*

W. A. GROSS  
Chief, Automotive Division

APPROVED:

*E.A. Noble*

E. A. NOBLE  
Assistant Deputy Director  
for Engineering Testing  
Development and Proof Services

APPENDICES

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APPENDIX A

Correspondence

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HEADQUARTERS  
ORDNANCE TANK-AUTOMOTIVE COMMAND  
DETROIT ARSENAL  
28251 VAN DYKE AVENUE  
CENTER LINE, MICHIGAN

HSpiro/mm/24-106

In Reply  
Refer to ORDMC-RM.1

26 March 1957

SUBJECT: Request for a Cost Estimate for a Ballistic Evaluation of  
the T13 Universal Carrier Hull

TO: Commanding General  
Aberdeen Proving Ground  
Maryland

ATTENTION: ORDBG-DP-TE, Mr. William Pless

1. Two Universal Carrier Hulls, one of which is to be fabricated  
from aluminum alloy and one from rolled homogeneous steel plate, will  
be shipped to your installation for ballistic evaluation.

2. A tentative test directive is inclosed for your information.

3. It is requested that a cost estimate of each phase be furnished  
by indorsement covering the test outlined in the inclosed test directive.

FOR THE CHIEF RESEARCH AND DEVELOPMENT DIVISION:

1 Incl

1. Test Directive  
(in dupe)

W. D. ENGLAND  
Chief, Materials Branch

CC  
OCO, ORDTT

## TEST DIRECTIVE

OBJECT: Vulnerability Test of the Hull of the Carrier, Personnel, Full Tracked, Airborne, T113

### DESCRIPTION OF MATERIAL:

Two T113 Hulls, one of which is to be fabricated mainly from 1-1/4" aluminum armor alloy and one mainly from 1/2" rolled armor plate. Brackets will be welded on the inside of the Hull.

### PROCEDURE:

In order to ascertain level of protection afforded by two different Universal Carrier Hulls (one utilizing the rolled armor plate and the other aluminum alloy) the following tests should be conducted on each Hull.

#### PHASE I

##### a. Blast Evaluation at Low Temperature:

- (1) Shocking of the weldments with 37mm HE projectile to determine the susceptibility of the weldments to cracking.
- (2) The shocking of the virgin plate with the 37mm HE projectile.

##### b. Vulnerability of the vehicles to fragments from 105mm HE round at 90, 50 and 20 ft:

- (1) Sides and roof of hull.
- (2) Grille openings.

##### c. Blast evaluation at ambient temperature. (Not required if no cracking is observed at low temperature.)

Shocking of weldments and virgin plates with 37mm HE projectile.

##### d. Projectile Fragmentation: The ballistic limit of the fragment simulators (.30 Cal., .50 Cal., 20mm and any intermediate size, if available) shall be determined when fired across and into the grilles at various degrees of obliquity (0°, 45°, 60°, and 70°).

##### e. The ballistic protection afforded by the armor plate and grille to impacts from .30 Cal. and .50 Cal. ball and AP projectiles at various degrees of obliquity (0°, 45°, and 60°).

##### f. Grenade Testing: Both the fragmentation and offensive grenade shall be used on the grilles.

g. Splash Testing: The capability of bullet splash from .30 Cal. ball, AP rounds, and grenades of entering various openings of the vehicle, such as doors, etc.

The order and method of testing is left to the discretion of Aberdeen Proving Ground. In addition, authorization is granted to conduct any other tests which they deem necessary.

#### PHASE II

The effect of blast from a light anti-tank mine exploded inboard under the first roadwheel. Under this phase Ordnance Tank-Automotive Command will send roadwheels and roadarms to APG. APG will then be required to attach the roadarms to the vehicle in order to establish mine protection. The floor plates of the vehicles are 3/8" aluminum alloy or 3/16" steel.

#### PHASE III

Different thicknesses of aluminum alloy will be tested against mines. The mine protection requirement will be specified as soon as CONARC and OCO inform this office. Your office may be required to weld additional plate to the floor and attach roadarms and roadwheels to the hull prior to this evaluation. The plate, roadarms and roadwheels will be furnished by this Command.

#### Attendance:

This office desires to be notified in advance of scheduled firings to permit attendance by interested personnel.

#### Reports:

A final report will be required. Distribution shall be in accordance with a distribution list which will be forwarded under separate cover.

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APPENDIX B  
Detailed Test Data  
Phase I

| <u>Hull Type</u> | <u>Round Number</u> | <u>Number Fragment Impacts</u> | <u>Number CP(P)</u> | <u>Remarks</u>   |
|------------------|---------------------|--------------------------------|---------------------|--|
| T113             | 1                   | 4                              | 0                   |  |
| T117             | 1                   | 0                              | 0                   | 1 fragment hit left front road wheel                           |
| T113             | 2                   | 2                              | 0                   |  |
| T117             | 2                   | 2                              | 0                   |  |
| T113             | 3                   | 5                              | 0                   |  |
| T117             | 3                   | 0                              | 0                   |  |
| T113             | 4                   | 4                              | 0                   |  |
| T117             | 4                   | 0                              | 0                   |  |
| T113             | 5                   | 3                              | 1                   | CP(P) 4"x $\frac{3}{4}$ " on lower hull side of 3/4" aluminum. |
| T117             | 5                   | 3                              | 0                   |  |
| T113             | 6                   | 7                              | 0                   |  |
| T117             | 6                   | 4                              | 0                   |  |
| T113             | 7                   | 1                              | 0                   |  |
| T117             | 7                   | 1                              | 0                   |  |
| T113             | 8                   | 3                              | 0                   |  |
| T117             | 8                   | 1                              | 0                   |  |

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105mm HE M1 - Static Detonation  
Hull Roof Plate - 90 Feet

| <u>Hull Type</u> | <u>Round Number</u> | <u>Number Fragment Impacts</u> | <u>Number CP(P)</u> | <u>Remarks</u>   |
|------------------|---------------------|--------------------------------|---------------------|--|
| T113             | 9                   | 3                              | 0                   |  |
| T117             | 9                   | 3                              | 0                   |  |
| T113             | 10                  | 8                              | 0                   |  |
| T117             | 10                  | 3                              | 0                   |  |
| T113             | 11                  | 11                             | 1                   | CP(P) 1-1/2" x 1-1/2" on 1-1/4" thick aluminum                     |
| T117             | 11                  | 1                              | 0                   |  |
| T113             | 12                  | 8                              | 1                   | CP(P) 1-1/2" x 5/8" on 1-1/4" thick aluminum                       |
| T117             | 12                  | 3                              | 0                   |  |
| T113             | 13                  | 3                              | 1                   | CP(P) 1-3/4" x 1" on 1-1/4" thick aluminum and pierced hull bottom |
| T117             | 13                  | 7                              | 0                   |  |
| T113             | 14                  | 7                              | 0                   |  |
| T117             | 14                  | 2                              | 0                   |  |
| T113             | 15                  | 3                              | 0                   |  |
| T117             | 15                  | 0                              | 0                   |  |
| T113             | 16                  | 6                              | 0                   |  |
| T117             | 16                  | 10                             | 0                   |  |

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105mm HE M1 - Static Detonation  
Hull Roof Plate - 50 Feet

| <u>Hull Type</u> | <u>Round Number</u> | <u>Number Fragment Impacts</u> | <u>Number CP(P)</u> | <u>Remarks</u>  |
|------------------|---------------------|--------------------------------|---------------------|---|
| T113             | 17                  | 15                             | 0                   | One fragment severed one louvre bar in grille over crew compartment.                              |
| T117             | 17                  | 12                             | 0                   | One fragment pierced engine grille leaving a 2-3/4" x 13/16" opening.                             |
| T113             | 18                  | 29                             | 2                   | CP(P) 1-3/4" x 1" on 1-1/4" thick aluminum. CP(P) 1-7/8" x 1" on engine grille.                   |
| T117             | 18                  | 19                             | 0                   |   |
| T113             | 19                  | 20                             | 0                   |   |
| T117             | 19                  | 11                             | 1                   | CP(P) 1-1/4" x 7/8" on plate covering commander's hatch opening. Passed through main floor plate. |

Hull Side Plate - 50 Feet

T113 - Left Side

T117 - Right Side

|      |    |    |   |  |
|------|----|----|---|--|
| T113 | 20 | 14 | 0 |  |
| T117 | 20 | 5  | 1 | CP(P) 4-1/4" x 5/8" on lower hull side plate   |
| T113 | 21 | 13 | 2 | CP(P) 1-1/4" x 5/8" CP(P) 1-3/4" x 13/16" on 3/4" aluminum lower hull side plate             |
| T117 | 21 | 6  | 1 | CP(P) 1-1/8" x 3/4" opening. Fragment did not penetrate plate. Hit on lower hull side plate. |
| T113 | 22 | 7  | 0 |  |
| T117 | 22 | 8  | 0 |  |

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105mm HE M1 - Static Detonation  
Hull Side Plate - 20 Feet

T115 - Left Side

T117 - Right Side

| <u>Hull Type</u> | <u>Round Number</u> | <u>Number Fragment Impacts</u> | <u>Number CP(P)</u> | <u>Remarks</u>   |
|------------------|---------------------|--------------------------------|---------------------|--|
| T115             | 23                  | 75                             | 2                   | CP(P) 1-1/4" x 3/4" CP(P) 1-3/8" x 3/8" on 1-1/4" thick aluminum side plate. Completely destroyed commander's cupola rear axle mounting bracket. |
| T117             | 23                  | 66                             | 0                   |  |

Hull Top - 20 Feet

|      |    |     |   |   |
|------|----|-----|---|---|
| T115 | 24 | 104 | 3 | CP(P) 1" x 1" CP(P) 1-1/8" x 5/8" CP(P) 1-3/8" x 3/4" all on 1-1/4" thick aluminum. |
| T117 | 24 | 84  | 0 |   |

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## APPENDIX C

### Detailed Test Data

#### Phase II

T113 Aluminum Hull - Left Side

Rebated Joints - 37-mm, HE, M54

#### Joint between upper Hull Side Plate and Vertical Nose Plate

Round No. 1 - Velocity 2553 fps. Hit 2" left of center of weld of vertical nose plate and 2-3/4" below sloped upper front plate. Face 5-1/2" F.Z. cracking. 7/8" plate crack - Rear surface - 3-1/4" F.Z. Plate crack 2". Loosened top weld on forward tubular bracket on upper hull side plate.

Round No. 2 - Velocity 2579 fps. Hit 1-3/8" left of center of weld and 4" above bottom edge of upper hull side plate. Face - 6-1/2" vertical F.Z. cracking and 4" horizontal F.Z. cracking. Rear Surface - 5-1/2" vertical F.Z. cracking - 1-3/16" transverse weld crack. Displaced tubular bracket loosened by Round No. 1. Tack weld on top mounting bracket of rear tubular container cracked.

#### Joint between upper Hull side plate and Sponson Floor Plate

Round No. 3 - Velocity 2467 fps. Hit 3/4" above bottom edge of upper hull side plate and 20-1/4" from nose. Face - 4-1/2" F.Z. 1/2" plate crack. Rear surface - 5" F.Z. cracking.

Round No. 4 - Velocity 2564 fps. Hit 3/8" above bottom edge of upper hull side plate and 38-1/2" from nose. Face - 1-7/8" F.Z. cracking. Rear surface - 4-1/8" F.Z. cracking. Secondary F.Z. 2-1/16".

Round No. 5 - Velocity 2586 fps. Hit 1" above bottom edge of upper hull side plate and 57" from nose. Face - 4-7/8" F.Z. cracking. Rear surface 6-1/2" F.Z. cracking - secondary F.Z. cracking 1-1/4".

#### Joint between upper Hull side Plate and Sponson Floor Plate

Round No. 6 - Velocity 2585 fps. Hit 1-1/2" above center line of weld and 96-5/8" from rear. Face - no weld area cracking - opening on face 3" x 1-1/4" - 1-3/4" plate crack - Rear surface - 3-1/2" F.Z. cracking - opening on back 3-7/8" x 3-1/8" w/65% back spall. Two plate cracks 2" - 1".

Round No. 7 - Velocity 2537 fps. Hit 1-1/4" above center line of weld and 81-1/2" from rear. Face - 1" F.Z. cracking - opening on face 1-1/2" x 1-1/2". Two plate cracks 1-1/4" - 1". Rear surface - 4-1/2" F.Z. cracking - punching started 2-7/8" x 3".

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Round No 8 - Velocity 2544 fps. Hit  $1\frac{1}{2}$ " above center line of weld and  $66\frac{1}{2}$ " from rear. Face - no weld area cracking - opening on face  $3\frac{1}{2}$ " x  $1\frac{7}{8}$ " plate crack  $1\frac{1}{8}$ ". Rear surface - 6" F.Z. cracking - opening on back  $5\frac{1}{2}$ " x  $2\frac{7}{8}$ " w/ $65\frac{1}{2}$  back spall.

Round No 9 - Velocity 2570 fps. Hit 2" above center line of weld and  $51\frac{1}{2}$ " from rear. Face - no weld area cracking -  $\frac{1}{2}$  circular crack  $1\frac{5}{8}$ ". Rear surface -  $1\frac{3}{4}$ " F.Z. cracking -  $3\frac{1}{2}$ " plate crack.

Round No 10 - Velocity lost. Hit  $1\frac{1}{2}$ " above center line of weld and  $35\frac{1}{2}$ " from rear. Face - no weld cracking - 6" circular plate crack - Rear surface 1" F.Z. cracking - 6" circular plate crack.

Round No 11 - Velocity lost - Hit  $1\frac{1}{4}$ " above center line of weld and  $19\frac{1}{2}$ " from rear. Face - 2" weld cracking on face -  $3\frac{1}{2}$ " circular plate crack - Rear surface -  $3\frac{3}{4}$ " F.Z. crack -  $1\frac{1}{2}$ " plate crack.

### Joint between upper Hull side Plate and Rear Hull Plate \*

Round No 12 - Velocity lost. Hit 2" left of vertical weld and 7" above bottom edge of plate. Face -  $2\frac{3}{4}$ " F.Z. cracking - Rear surface -  $1\frac{1}{2}$ " weld cracking and 1" secondary F.Z. cracking.

### Conventional Joint - Right Side

### Joint between upper Hull side Plate and Rear Plate \*

Round No 13 - Velocity 2540 fps. Hit 1" left of vertical seam on rear and  $6\frac{1}{2}$ " above lower edge of upper hull side plate. Face - no weld cracking. Rear surface -  $3\frac{1}{2}$ " F.Z. cracking

### Joint between upper Hull side Plate and Sponson Floor Plate

Round No 14 - Velocity 2540 fps. Hit  $1\frac{1}{2}$ " above center line of weld and  $18\frac{1}{2}$ " from rear. Face - no weld area cracking -  $4\frac{1}{2}$ " Plate cracking. Rear surface -  $4\frac{1}{2}$ " F.Z. cracking. Two plate cracks 1" and  $5\frac{1}{8}$ ".

Round No 15 - Velocity 2576 fps. Hit  $1\frac{1}{2}$ " above center line of weld and  $36\frac{1}{2}$ " from rear. Face - no weld damage - opening on face  $1\frac{1}{2}$ " x  $1\frac{1}{2}$ ". Rear surface - Exit diameter  $1\frac{3}{4}$ " x  $1\frac{1}{2}$ " w/ $65\frac{1}{2}$  back spall -  $2\frac{7}{8}$ " x  $1\frac{7}{8}$ " -  $1\frac{1}{2}$ " Plate crack. No weld damage.

Round No 16 - Velocity 2548 fps. Hit  $1\frac{1}{2}$ " above center line of weld and  $52\frac{1}{4}$ " from rear. Face - no weld damage - 2" plate crack. Rear surface -  $4\frac{1}{2}$ " F.Z. cracking -  $5\frac{1}{8}$ " Plate crack.

Round No 17 - Velocity 2557 fps. Hit  $1\frac{1}{2}$ " above center line of weld and  $100\frac{1}{2}$ " from nose. Face - no weld area cracking -  $5\frac{1}{2}$ " plate crack. Rear surface  $3\frac{1}{4}$ " F.Z. cracking. Two plate cracks  $1\frac{3}{4}$ " - 2".

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Round No 18 - Velocity 2520 fps. Hit  $1\frac{1}{2}$ " above center line of weld and  $8\frac{1}{2}$ " from nose. Face - no weld area cracking - opening on face  $3\frac{3}{4}$ " x 2". Rear surface -  $4\frac{3}{8}$ " F.Z. - opening on back  $4"$  x 2" w/65% back spall  $2\frac{1}{4}$ " x 3". Two plate cracks  $3/4"$  -  $1\frac{1}{2}$ ".

Round No 19 - Velocity 2524 fps. Hit  $2\frac{1}{2}$ " above center line of weld and 68" from nose. Face - no weld area cracking -  $5\frac{1}{2}$ " plate crack. Rear surface - no weld area cracking -  $6\frac{3}{4}$ " horizontal plate crack.

Round No 20 - Velocity 2532 fps. Hit  $1\frac{5}{8}$ " above center line of weld and  $5\frac{1}{4}$ " from nose. Face - no weld area cracking - 5" plate crack. Rear surface -  $4\frac{1}{2}$ " F.Z. Two plate cracks 2" -  $2\frac{1}{8}$ "

Round No 21 - Velocity 2536 fps. Hit  $1\frac{3}{8}$ " above center line of weld and  $3\frac{3}{4}$ " from nose. Face - no weld area cracking - opening on face  $1\frac{3}{4}$ " x  $1\frac{3}{4}$ ". Two plate cracks  $1\frac{5}{8}$ " -  $1\frac{1}{2}$ ". Rear surface -  $4\frac{1}{4}$ " F.Z. opening on back 2" x  $1\frac{3}{4}$ ". Two plate cracks 1" -  $1\frac{1}{2}$ ".

Round No 22 - Velocity 2524 fps. Hit  $1\frac{1}{4}$ " above center line of weld and  $15\frac{1}{2}$ " from nose. Face -  $9\frac{1}{4}$ " weld cracking -  $3\frac{3}{8}$ " plate crack - transverse weld cracking -  $2\frac{7}{8}$ " plate crack.

### Joint between upper Hull side Plate and Vertical Nose Plate

Round No 23 - Velocity 2516 fps. Hit  $1\frac{1}{4}$ " left of center of weld of vertical nose and 5" above bottom edge of upper hull side plate. Face -  $3\frac{1}{2}$ " weld cracking. Rear surface -  $3\frac{3}{4}$ " weld cracking.

### Interlocking Joints between upper Hull side Plate and upper Sloped Nose Plate

Round No 24 - Velocity 2516 fps. Hit  $2\frac{1}{2}$ " below center of weld above sloped upper nose plate and  $4\frac{3}{8}$ " left of center line of weld of vertical nose plate. Joint tested in compression. Face  $1\frac{1}{2}$ " weld cracking  $1\frac{3}{4}$ " x  $1\frac{3}{4}$ " punching started. Rear surface -  $1\frac{1}{2}$ " HAZ cracking Punching started  $2\frac{3}{4}$ " x  $2\frac{3}{8}$ ".

Round No 25 - Velocity 2545 fps. Hit  $1\frac{1}{4}$ " below center line of weld of sloped upper nose plate and  $27\frac{1}{2}$ " from vertical nose plate. Joint tested in Shear. Face -  $7\frac{3}{8}$ " F.Z. cracking. Rear surface  $7\frac{3}{4}$ " F.Z. cracking.

### Inter-locking Joints - Right Side Joint between upper Hull side Plate and Roof Plate

Round No 26 - Velocity 2510 fps. Hit 1" below center of weld and 109" from rear. Joint tested in shear condition. Face -  $4\frac{3}{8}$ " F.Z. cracking -  $1\frac{1}{4}$ " plate crack. Rear surface -  $6\frac{1}{2}$ " weld cracking.

Round No 27 - Velocity 2530 fps. Hit on edge of plate 85" from rear. Joint tested in compression condition. Face - no cracking. Rear surface - no cracking.

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Round No 28 - Velocity 2494 fps. Hit 5/8" below center of weld and 6 1/2" from rear. Joint tested in shear condition. Face - 7 1/4" weld cracking. Rear surface - 8 1/8" weld cracking - 1/2" transverse weld crack.

Round No 29 - Velocity 2502 fps. Disregard.

Round No 30 - Velocity 2510 fps. Hit 1/2" below center line of weld and 14 3/4" from rear. Joint tested in shear condition. Face - 7 1/4" weld cracking. Rear surface - 8" weld cracking - 2" plate crack.

### Joint between upper Hull side Plate and Rear Hull Plate \*

Round No 31 - Velocity 2514 fps. Hit 1" right of center line of weld and 11 7/8" below top edge of plate. Face - no cracks. Rear surface - 1 3/4" weld cracking - secondary weld cracking 1 3/8".

### Inter-locking Joints - Left Side

#### Joint between upper Hull side Plate and Rear Hull Plate \*

Round No 32 - Velocity 2514 fps. Hit 2 1/2" left of center line of weld and 10 1/2" below top edge of plate. Face - no weld area damage - opening on face 2 1/2" x 2". Rear surface - no weld area damage. Punching started 3 1/4" x 3". Displaced lower center retaining strip of fuel cell inspection door.

#### Joint between Roof Plate and upper Hull side Plate

Round No 33 - Velocity 2510 fps. Hit 5/8" below center line of weld and 15" from rear. Face - no weld cracking - 7 1/2" plate crack. Rear surface - 6 1/2" F.Z. cracking. Displaced top retaining strip of fuel cell inspection door.

Round No 34 - Velocity 2535 fps. Hit 1 3/8" below top edge of plate and 37 5/8" left of rear. Face - no weld area cracking - 11 1/4" plate crack. Rear surface - 11 1/4" weld cracking - 1/2" transverse weld cracking - 3 7/8" plate crack. Broke rear tack weld on 'V' shaped hanger on roof of fuel cell compartment.

Round No 35 - Velocity 2551 fps. Hit 1 1/4" below top edge of plate and 59 1/2" from rear. Face - no weld area cracking - 12 3/8" plate crack. Rear surface - 12 1/2" weld cracking. Fillet weld on outboard side of leading edge of fuel cell compartment split extending from roof plate to sponson floor plate. Also 6 1/8" weld cracking in fillet weld between top of leading edge of fuel cell compartment and hull roof plate - 3 3/16" F.Z. crack in fillet weld joining leading edge of fuel cell compartment with the sponson floor plate. Tack weld on aft 'L' shaped bracket on upper hull side plate cracked.

Round No 36 - Velocity 2547 fps. Hit 1 1/8" below top edge of plate and 82 5/8" from rear. Face - no weld area cracking - 11 1/4" plate crack. Rear surface - 11 1/4" weld area cracking.

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Round No 37 - Velocity 2514 fps. Hit 1" below top edge of plate and  $110\frac{1}{4}$ " from rear. Face - no weld area cracking - 10" plate crack. Rear surface 9" weld cracking 1" F.Z. cracking.

Round No 38 - Velocity 2529 fps. Hit  $1\frac{1}{4}$ " below centerline of weld and  $131\frac{1}{4}$ " from rear. Face - no weld area cracking -  $9\frac{1}{2}$ " plate crack. Rear surface -  $10\frac{1}{4}$ " F.Z. cracking. Full length crack noted in fillet weld attaching diagonally set structural member to upper hull side plate on interior.

### Joint between upper Hull side Plate and Sloped upper Nose Plate

Round No 39 - Velocity 2521 fps. Hit  $1\frac{1}{4}$ " below center line of weld and 28" from vertical nose plate. Face - no weld area cracking -  $11\frac{1}{4}$ " plate crack. Rear surface - 12" F.Z. cracking - 4" plate crack. Displaced rear tubular bracket.

T113 - Rear

Right Side

### Joint between Rear Hull Plate and Roof Plate

Round No 40 - Velocity 2501 fps. Hit  $2\frac{1}{4}$ " below center line of weld and  $7\frac{3}{4}$ " from right edge. Face - no weld cracking  $1\frac{7}{8}$ " x  $1\frac{7}{8}$ " opening on face. Rear surface -  $3\frac{1}{4}$ " F.Z. cracking. Exit diameter  $2\frac{1}{4}$ " x  $2\frac{3}{16}$ " with 50% back spall. Displaced small bracket on rear hull plate.

### Joint between upper Hull side Plate and Rear Plate

Round No 41 - Velocity 2545 fps. Hit 1" left of right edge and  $12\frac{3}{4}$ " above bottom edge. Face - no weld area cracking. Sheared bottom Jerry can retaining strip and right hand can strap bracket. Rear surface - 2" F.Z. cracking.

T113 - Hull Rear

Left Side

### Joint between upper Hull side Plate and Hull Rear Plate

Round No 42 - Velocity 2541 fps. Hit  $1\frac{1}{4}$ " right of left edge and  $14\frac{3}{8}$ " above bottom edge. Face - no weld area cracking -  $1\frac{1}{4}$ " plate cracking. Rear surface 2" F.Z. cracking.

### Joint between Hull Rear Plate and Roof Plate

Round No 43 - Velocity 2549 fps. Hit  $1\frac{3}{4}$ " below center line of weld and  $7\frac{1}{4}$ " right of left edge. Face - no weld area cracking - 7" circular plate crack. Sheared aluminum catch on gasoline filler cap. Rear surface - 1" F.Z. cracking -  $3\frac{3}{4}$ " plate crack'ng  $2\frac{1}{4}$ " plate cracking.

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## Joint between Rear Hull Plate and Sponson Floor Plate

Round No 44 - Velocity 2531 fps. Hit  $1\frac{1}{4}$ " above center line of weld and  $4\frac{3}{4}$ " right of left edge. Face -  $6\frac{1}{4}$ " weld cracking - plate cracks -  $5\frac{5}{16}$ " -  $1\frac{3}{4}$ ". Displaced shovel bracket. Rear surface  $6\frac{3}{8}$ " weld cracking - 4" plate.

## Joint between Rear Hull Plate and Sponson Floor Plate

Round No 45 - Velocity 2523 fps. Hit 2" above center line of weld and 10" left of right edge. Face -  $4\frac{7}{8}$ " weld cracking -  $4\frac{1}{4}$ " circular plate crack. Rear surface  $5\frac{1}{4}$ " weld crack - Secondary F.Z. 5" tongue crack 3" x 2".

T113 - Front - Left

## Joint between upper Sloped Plate and Vertical Nose Plate

Round No 46 - Velocity 2485. Hit  $2\frac{3}{8}$ " below center line of weld and  $27\frac{3}{8}$ " from left edge. Face no cracking. Rear surface - no cracking.

Round No 47 - Velocity 2520 fps. Hit  $2\frac{3}{8}$ " below center line of weld and  $27\frac{3}{8}$ " from left edge. Face - no cracking. Rear surface - no cracking.

## Joint between Vertical Nose Plate and Sponson Floor Plate Left Side

Round No 48 - Velocity 2506 fps. Hit 9" to the left of the center from the bottom of the skirt plate. Face -  $5\frac{1}{2}$ " x  $3\frac{1}{2}$ ". Diameter of the opening 3" F.Z. cracking 2" F.Z. cracking  $3\frac{1}{4}$ " and 1" weld cracking. Rear surface - no cracking.

Vertical Nose Plate

T113 - Right Side

## Joint between Vertical Nose Plate and Sloped upper Plate

Round No 49 - Velocity 2523 fps. Hit 7" right of left edge of plate and on weld. Face - no weld cracking. Rear surface - no cracking.

Vertical Nose Plate

## Joint between Vertical Nose Plate and Sponson Floor Plate - Right Side

Round No 50 - Velocity 2503 fps. Hit  $8\frac{1}{4}$ " left from vertical weld and directly on weld joint. Face -  $10\frac{1}{4}$ " weld cracking on scurting plate joining to hull  $2\frac{3}{8}$ ", 4",  $2\frac{1}{2}$ " plate cracks. Rear surface 3" F.Z. cracking.

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T113 - Left Side

### Rupture of Upper Hull Side Plate

37-MM HE M54

Round No 1R - Velocity lost. Hit  $27\frac{1}{4}$ " from rear and 19" below top edge. Face -  $7\frac{1}{2}$ " circular crack. Rear surface tongue crack  $3\frac{1}{4}$ " x 3" - 2" plate crack.

Round No 2R - Velocity 2518 fps. Hit  $50\frac{1}{2}$ " from rear edge and 18" from top edge. Face -  $2\frac{3}{8}$ " plate crack. Deformation  $2\frac{1}{16}$ ". Rear surface - large bulge with T shaped crack 2" x 2".

Round No 3R - Velocity 2448 fps. Hit 70" from rear and  $17\frac{3}{8}$ " below top edge. Face - no cracking deformation  $1\frac{3}{4}$ ". Rear surface large bulge - no cracking.

Round No 4R - Velocity 2498 fps. Hit  $88\frac{3}{8}$ " from rear and  $17\frac{1}{2}$ " from top edge. Face deformation 2",  $2\frac{1}{2}$ " plate crack. Rear surface - large bulge  $4\frac{1}{4}$ " horizontal plate crack.

Round No 5R - Velocity 2471 fps. Hit  $106\frac{1}{2}$ " from rear and 16" from top edge. Face - no cracking deformation  $1\frac{3}{4}$ ". Rear surface large bulge - no cracking.

T117 - Left Side

37-MM HE M54 Projectile

### Joint between upper Hull side Plate and Hull Rear Plate

Round No 1 - Velocity 2531 fps. Hit 2" left of center of weld and 10" from top. Face - no weld area cracking. Rear surface - no weld area cracking. Two tack welds broken on outboard edge of sloped plate at top rear of fuel cell compartment. Three tack welds broken on outboard edge of forward bulkhead of fuel cell compartment.

### Joint between upper Hull side Plate and Roof Plate

Round No 2 - Velocity 2540 fps. Hit 2" below center line of weld and  $27\frac{3}{8}$ " from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 3 - Velocity 2523 fps. Hit  $3\frac{1}{4}$ " below center line of weld and  $45\frac{3}{4}$ " from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 4 - Velocity 2548 fps. Hit 1" below center line of weld and  $72\frac{3}{4}$ " from rear. Face -  $4\frac{1}{2}$ " weld cracking. Rear surface  $2\frac{3}{16}$ " weld cracking -  $3\frac{5}{8}$ " F.Z. cracking.

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Round No 5 - Velocity 2519 fps. Hit  $7/8$ " below center line of weld and  $9\frac{1}{4}$ " from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 6 - Velocity 2531 fps. Hit  $3/4$ " below center line of weld and  $11\frac{1}{2}$ " from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 7 - Velocity 2531 fps. Hit  $3/4$ " below center line of weld and  $136\frac{1}{2}$ " from rear. Face  $2\frac{3}{4}$ " weld cracking. Rear surface 1" weld cracking  $2\frac{3}{8}$ " F.Z. cracking.

### Joint between upper Hull side Plate and Sloped upper Nose Plate

Round No 8 - Velocity 2519 fps. Hit  $3/4$ " below center line of weld and  $26\frac{1}{2}$ " above vertical nose plate. Face -  $8\frac{3}{8}$ " weld cracking. Rear surface - 9" F.Z. cracking.

### Joint between upper Hull side Plate and Sponson Floor Plate

Round No 9 - Velocity 2523 fps. Hit 1" above center line of weld and 3" from nose. Face  $4\frac{1}{2}$ " weld cracking on horizontal seam and  $2\frac{1}{2}$ " F.Z. cracking on vertical seam. Rear surface  $4\frac{1}{4}$ " F.Z. cracking on horizontal seam and 4" F.Z. cracking on Vertical seam.

Round No 10 - Velocity 2519 fps. Hit  $5\frac{1}{2}$ " above center line of weld and  $20\frac{1}{4}$ " from nose. Face - no weld area cracking -  $1\frac{5}{8}$ " plate crack. Rear surface  $3\frac{1}{4}$ " HAZ cracking - dislodged locking clamp on oil can bracket. Sheared off bottom rivet head holding tubular oil can container to mounting bracket.

Round No 11 - Velocity 2564 fps. Hit 1" above center of weld and  $37\frac{1}{2}$ " from nose. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 12 - Velocity 2528 fps. Hit 1" above center line of weld and 55" from nose. Face - no weld area cracking - Rear surface - no weld area cracking.

Round No 13 - Velocity 2520 fps. Hit  $1\frac{1}{2}$ " above center of weld and  $72\frac{1}{2}$ " from nose. Face - no weld area cracking -  $6\frac{3}{16}$ " plate crack. Rear surface  $1\frac{1}{2}$ " F.Z. cracking. Two plate cracks 3" and  $2\frac{1}{2}$ ".

Round No 14 - Velocity 2533 fps. Hit  $3/4$ " above center line of weld and  $91\frac{1}{4}$ " from nose. Face opening on upper hull side plate  $2\frac{1}{8}$ " x  $1\frac{1}{4}$ ". opening on sponson floor plate  $1\frac{3}{8}$ " x  $1\frac{5}{8}$ ". Plate crack 2". Rear surface  $1\frac{3}{4}$ " F.Z. cracking - opening on rear  $2\frac{3}{8}$ " x 2" (Low or detonation).

Round No 15 - Velocity 2523 fps. Hit  $1\frac{7}{8}$ " above center line of weld and 109" from nose. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 16 - Velocity 2516 fps. Hit  $1\frac{1}{4}$ " above center line of weld and  $127\frac{1}{2}$ " from nose. Face - no weld area cracking. Rear surface - no weld area cracking. Loosened eight tack welds on outboard edge of forward bulkhead to fuel cell compartment.

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Round No 17 - Velocity 2520 fps. Hit 1" above center line of weld and  $1\frac{1}{4}$ " from nose. Face - no weld area cracking. Rear surface - no weld area cracking.

### Joint between upper Hull side Plate and Hull Rear Plate

Round No 18 - Velocity 2508 fps. Hit 1" left of center line of weld and  $8\frac{3}{4}$ " above bottom edge. Face  $10\frac{5}{8}$ " weld cracking. Rear surface -  $9\frac{1}{2}$ " F.Z. cracking.

### Joint between upper Hull side Plate - Vertical and Sloped upper Nose Plate

Round No 19 - Velocity 2504 fps. Hit  $3\frac{1}{4}$ " right of center line of weld and  $1\frac{1}{2}$ " above bottom edge. Face  $4\frac{3}{4}$ " vertical weld cracking  $5\frac{1}{4}$ " weld cracking along diagonal weld seam along sloped nose plate. Rear surface 5" F.Z. cracking along slope and 4" F.Z. cracking on vertical weld.

### Joint between upper Hull side Plate and sloped upper Nose Plate

Round No 20 - Velocity 2537 fps. Hit  $7\frac{1}{8}$ " below center line of weld and  $16\frac{1}{2}$ " from nose. Face  $13\frac{1}{2}$ " weld cracking. Rear surface 1" weld cracking 12" F.Z. cracking.

### T117 - Right Side

### Joint between upper Hull side Plate and Hull Rear Plate

Round No 21 - Velocity 2557 fps. Hit  $1\frac{1}{2}$ " right of center line of weld and  $8\frac{3}{4}$ " above bottom edge. Face  $8\frac{7}{8}$ " weld cracking. Rear surface -  $8\frac{1}{4}$ " F.Z. cracking.

### Joint between upper Hull side Plate and Sponson Floor Plate

Round No 22 - Velocity 2533 fps. Hit  $1\frac{1}{4}$ " above center line of weld and 18" from rear. Face - no weld area cracking. Rear surface - 2" HAZ cracking.

Round No 23 - Velocity 2504 fps. Hit 1" above center line of weld and  $3\frac{1}{4}$ " from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No 24 - Velocity 2528 fps. Hit  $7\frac{1}{8}$ " above center line of weld and  $5\frac{1}{4}$ " from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No 25 - Velocity 2533 fps. Hit  $1\frac{1}{4}$ " above center line of weld and  $6\frac{1}{2}$ " from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No 26 - Velocity 2533 fps. Hit  $3\frac{1}{4}$ " above center line of weld and  $8\frac{1}{4}$ " from rear. Face  $3\frac{5}{8}$ " weld cracking. Rear surface - 4" weld cracking.

Round No 27 - Velocity 2509 fps. Hit  $1\frac{1}{4}$ " above center line of weld and 100" from rear. Face - no weld cracking. Rear surface  $2\frac{1}{4}$ " F.Z. cracking.

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Round No. 28 - Velocity 2517 fps. Hit  $1\frac{1}{4}$ " above center line of weld and  $1\frac{1}{2}$ " from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No. 29 - Velocity 2529 fps. Hit 1" above center line of weld and  $1\frac{3}{4}$ " from rear. Face - no weld cracking. Rear surface - no welding cracking.

Round No. 30 - Velocity 2509 fps. Hit 1" above center line of weld and  $2\frac{1}{2}$ " from nose. Face - no weld cracking. Rear surface - no welding cracking.

Round No. 31 - Velocity 2538 fps. Hit 1" above center line of weld and 2" from nose. Face  $4\frac{1}{4}$ " F.Z. crack on vertical weld -  $2\frac{1}{2}$ " HAZ on horizontal weld -  $2\frac{1}{2}$ " plate crack. Rear surface - 4" F.Z. cracking on vertical weld -  $2\frac{1}{2}$ " HAZ on horizontal weld -  $2\frac{1}{2}$ " plate crack.

### Joint between upper Hull side Plate, Vertical and Sloped Nose Plate

Round No. 32 - Velocity 2505 fps. Hit 2" from center line of vertical weld and 2" below center line of sloped upper nose plate weld. Face - no weld cracking. Rear surface - no weld area cracking.

### Joint between upper Hull side Plate and Sloped Nose Plate

Round No. 33 - Velocity 2517 fps. Hit 1" below center line of sloped weld and  $1\frac{1}{2}$ " from nose. Face  $6\frac{3}{4}$ " F.Z. cracking. Rear surface 7" F.Z. cracking.

Round No. 34 - Velocity 2509 fps. Hit 1" below center line of weld at intersection of upper hull side plate, sloped nose plate and roof plate. Face 3" HAZ crack. Rear surface 3" HAZ crack.

### Joint between upper Hull side Plate and Roof Plate

Round No. 35 - Velocity 2505 fps. Hit  $1\frac{1}{4}$ " below center line of weld and 67" from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No. 36 - Velocity 2517 fps. Hit 1" below center line of weld and 51" from rear. Face - no weld cracking. Rear surface 1" HAZ cracking. Displaced small bracket.

Round No. 37 - Velocity 2528 fps. Hit  $3\frac{1}{4}$ " below center line of weld and 35" from rear. Face - no weld area cracking. Rear surface 2" F.Z. cracking.

Round No. 38 - Velocity 2532 fps. Hit  $1\frac{1}{4}$ " below center line of weld and 2" from rear. Face - 1" weld crack. Rear surface  $3\frac{1}{2}$ " F.Z. cracking - secondary weld crack  $\frac{1}{4}$ ".

Round No. 39 - Velocity 2540 fps. Hit 1" below center line of weld and  $18\frac{1}{2}$ " from rear. Face -  $3\frac{1}{4}$ " F.Z. crack. Rear surface 3" F.Z. crack.

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### Hull Rear

#### Joint between Left Rear and Roof Plate

Round No 40 - Velocity 2512 fps. Hit  $1\frac{1}{4}$ " below center line of weld and  $12\frac{1}{2}$ " from left edge. Face - no weld cracking. Rear surface -  $1\frac{1}{4}$ " F.Z. cracking. Displaced small bracket for outside of vehicle. Fragments of shell entered crew compartment through seal of rear ramp.

#### Joint between upper Hull side Plate and Hull Rear Plate

Round No 41 - Velocity 2578 fps. Hit 1" from center of weld and 19" below top of vehicle. Face -  $3\frac{1}{2}$ " weld crack. Rear surface 4" F.Z. crack - cracked 6 tack welds holding main fuel cell bulkhead to rear hull plate.

#### Joint between Rear Hull Plate and Sponson Floor Plate

Round No 42 - Velocity 2532 fps. Hit  $3\frac{1}{4}$ " above center line of weld and 7" from left edge. Face -  $3\frac{1}{2}$ " weld crack. Rear surface - 4" weld crack.

### Rear Hull Plate - Right Side

#### Joint between Rear Hull Plate and upper Hull side Plate

Round No 43 - Velocity 2287 fps. Hit  $1\frac{1}{4}$ " from right edge and  $16\frac{1}{2}$ " below top edge. Face - no weld area cracking. Rear surface - no weld area cracking  $3\frac{1}{4}$ " surface plate crack.

#### Joint between Rear Hull Plate and Sponson Floor Plate

Round No 44 - Velocity 2540 fps. Hit  $5\frac{1}{8}$ " above center of weld and left of right edge. Face -  $4\frac{1}{4}$ " weld crack. Two plate cracks  $1\frac{1}{4}$  - 1". Rear surface  $5\frac{1}{2}$ " weld crack 1" plate crack.

#### Joint between Rear Hull Plate and Roof Plate

Round No 45 - Velocity 2600 fps. Hit  $3\frac{1}{9}$ " below center line of weld and  $12\frac{1}{2}$ " from edge. Face - no weld area cracking. Rear surface - no weld area cracking. Large upper mounting bracket on right rear of ramp broken loose in one side in HAZ. Blast from shell displaced rubber gasket on right side of ramp.

#### Joint between Rear Hull Plate and Upper Hull side Plate

Round No 46 - Velocity 2613 fps. Hit  $\frac{1}{2}$ " from right edge and 8" below top edge. Face 1" weld crack. Rear surface 3" F.Z. crack camer bracket directly behind impact cracked but not displaced.

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Front

T117 - Right Side

## Joint between Vertical Nose Plate and Sponson Floor Plate

Round No 47 - Velocity 2551 fps. Hit on weld and 11 3/8" from right edge. Face - no weld cracking. Displaced splash plate at front of sponson floor plate. Rear surface - no cracks.

## Joint between Vertical Nose Plate and upper Sloped Plate

Round No 48 - Velocity 2509 fps. Hit 8" from right edge and 3/4" below top edge. Face - no cracks. Rear surface - no cracks.

Left Side 57-mm PPM1001

## Joint between Vertical Nose Plate and upper Sloped Plate

Round No 49 - Velocity 794 fps. Hit 33 $\frac{1}{2}$ " from left edge and 1 1/8" below top edge. Face no cracking. Rear - no cracking.

Round No 50 - Velocity 807 fps. Hit 20 $\frac{1}{4}$ " from left edge and 1 $\frac{1}{2}$ " below top edge. Face no cracking. Rear surface - no cracking.

Round No 51 - Velocity 804 fps. Hit 1 $\frac{1}{2}$ " below top edge and 9 3/16" from left edge. Face - no cracking. Rear surface - no cracking.

## Joint between Vertical Nose Plate and Sponson Floor Plate

Round No 52 - Velocity 809 fps. Hit 2" above center line of weld and 10" from left edge. Face - no structural weld cracking 13 7/8" weld cracking on skirting plate. Rear surface - no cracking.

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Resistance of Main Armor to H.E. Shell Burst

37-mm H.E. M54

T117 Hull - Left upper side Plate

Round No. 1R - Velocity 2541 fps. Hit 24 5/8" from rear and 14 3/4" below top edge. Face - punching out  $3\frac{1}{4}$ " x 3 1/8". Four plate cracks 1 3/4" - 1 1/2" - 1 1/2" - 1". Rear surface - punching out  $3\frac{1}{4}$ " x  $3\frac{1}{2}$ ". Two plate cracks 2" - 1 1/2". Disregard - low order detonation of fuze.

Round No. 2R - Velocity 2509 fps. Hit 39 3/4" from rear and 15" below top edge. Face - no cracks. Depth of deformation 1 1/2". Rear surface large bulge - no cracks.

Round No. 3R - Velocity 2636 fps. Hit 57" from rear and 16" below top edge. Face - no cracks. Depth of deformation 1 5/8". Rear surface - Large bulge - no cracks.

Round No. 4R - Velocity 2717 fps. Hit 74 1/4" from rear and 15 1/2" below top edge. Face no cracks. Depth of deformation 1 3/4". Rear surface large bulge - no cracks.

Round No. 5R - Velocity 2832 fps. Hit 92 1/4" from rear and 15 3/4" from top edge. Face - two plate cracks 1" - 1 5/8", Depth of deformation 1 5/8". Rear surface - large bulge - 1" plate crack - displaced small bracket.

Round No. 6R - Velocity 2844 fps. Hit 108" from rear edge and 15 1/8" below top edge. Face - no plate cracking. Depth of deformation 1 1/8". Rear surface - large bulge - no cracking.

Round No. 7R - Velocity 2844 fps. Hit 124 1/2" from rear and 15" below top edge. Face - no cracking. Depth of deformation - 1 11/16". Rear surface - large bulge - no cracking. Displaced one shock mounting bracket at inner side of upper hull side plate.

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## APPENDIX D

### Detailed Test Data

#### Phase III

##### RESISTANCE TO PENETRATION

T113

Upper Hull Side Plate - Right Side

##### Cal. 50 AP M2 - 0° Obliquity

| <u>Rd. No.</u> | <u>Velocity</u> | <u>CP(P)/PP(P)</u> | <u>Remarks</u>  |
|----------------|-----------------|--------------------|---|
| 1              | 1857            | CP(P)              | Exit diameter $\frac{1}{2}$ " x $\frac{1}{2}$ "                       |
| 2              | 1351            | PP(P)              | Slight bulge - No cracking  |
| 3              | 1666            | CP(P)              | Exit diameter $\frac{1}{2}$ " x $\frac{1}{2}$ "                       |
| 4              | 1496            | CP(P)              | Large bulge, $5/8$ " Horizontal crack - Nose through plate.           |
| *5             | 1458            | CP(P)              | Large bulge- $3/8$ " vertical crack, $\frac{1}{2}$ " horizontal crack |
| *6             | 1425            | PP(P)              | Slight bulge - No cracking  |

\* Protection Ballistic Limit : 1442 fps

##### Cal. 50 Ball M2 - 0° Obliquity

|    |      |       |   |
|----|------|-------|---|
| 1  | 1563 | CP(P) | Exit diameter $\frac{1}{4}$ " x $\frac{1}{4}$ "<br>Projectile in plate.       |
| 2  | 1495 | PP(P) | Large bulge - Hair cracks   |
| 3  | 1448 | PP(P) | Large bulge - $\frac{1}{2}$ " Horizontal crack                                |
| *4 | 1504 | PP(P) | Large bulge $\frac{1}{2}$ " Horizontal crack- $\frac{1}{4}$ " Vertical crack  |
| *5 | 1507 | CP(P) | Large bulge $\frac{1}{2}$ " Horizontal crack - $\frac{1}{2}$ " Vertical crack |

\* Protection Ballistic Limit : 1506 fps

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**CONFIDENTIAL**Cal. 30 AP M2 - 0° Obliquity

| <u>Rd. No.</u> | <u>Velocity</u> | <u>CP(P)/PP(F)</u> | <u>Remarks</u>   |
|----------------|-----------------|--------------------|--|
| 1              | 1947            | PP(P)              | Medium bulge - No cracking                             |
| 2              | 2105            | CP(P)              | Projectile through plate                               |
| 3              | 1982            | PP(P)              | Large bulge - No cracking                              |
| *4             | 2051            | CP(P)              | Nose through plate $\frac{1}{4}$ " - 1/8" plate cracks |
| 5              | 1975            | PP(P)              | Large bulge - No cracks                                |
| 6              | 1483            | PP(P)              | No bulge   |
| 7              | 2125            |                    | Disregard  |
| *8             | 2050            | PP(P)              | Large bulge - No cracks                                |

\* Protection Ballistic Limit = 2051 fps

20-mm Fragment Simulator 0° Obliquity

|    |      |       |                          |
|----|------|-------|--------------------------|
| 1  | 1510 | PP(P) | Large bulge - No cracks  |
| *2 | 1941 | CP(P) | Exit diameter 1" x 1"    |
| 3  | 1886 | PP(P) | Punching started 1" x 1" |
| *4 | 1896 | PP(P) | Punching started 1" x 1" |

\* Protection Ballistic Limit = 1919 fps

Cal. 30 AP M2 - 45° Obliquity

|     |      |       |   |
|-----|------|-------|---|
| 1   | 2531 |       | Disregard   |
| 2   | 2531 | PP(P) | No bulge - No cracking  |
| 3   | Lost |       |   |
| 4   | 3088 | PP(P) | Slight bulge  |
| 5   | 3281 | CP(P) | Exit diameter $\frac{1}{4}$ " x $\frac{1}{4}$ " - 5/16" plate crack |
| 6   | 3199 | CP(P) | Exit diameter 5/16" x 5/16" - 5/16" plate crack                     |
| 7   | 3113 | PP(P) | Large bulge - Punching started                                      |
| 8   | 3099 | PP(P) | Slight bulge - No cracking  |
| *9  | 3177 | CP(P) | Exit diameter 5/16" x 5/16"   |
| *10 | 3127 | PP(P) | Medium bulge - No cracking  |

\* Protection Ballistic Limit = 3152 fps

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**CONFIDENTIAL**Cal. 50 AP M2 - 45° Obliquity

| <u>Rd. No.</u> | <u>Velocity</u> | <u>CP(P)/PP(P)</u> | <u>Remarks</u>   |
|----------------|-----------------|--------------------|--|
| 1              | 2044            | PP(P)              | Slight bulge - No cracks                                     |
| *2             | 2180            | CP(P)              | Exit diameter $7/16"$ x $7/16"$ -<br>$5/8"$ horizontal crack |
| *3             | 2143            | PP(P)              | No bulge - No cracks   |

\* Protection Ballistic Limit = 2162 fps

20-mm Fragment Simulator - 45° Obliquity

|    |      |       |   |
|----|------|-------|---|
| 1  | Lost |       | Disregard   |
| 2  | 2782 | PP(P) | Large bulge - 1" horizontal crack                   |
| 3  | 2702 | PP(P) | Large bulge - No cracks                             |
| 4  | 2798 | PP(P) | Large bulge - $1\frac{1}{4}$ " horizontal crack     |
| *5 | 2846 | PP(P) | Large bulge - Punching started $1\frac{3}{4}"$ x 1" |
| *6 | 2879 | CP(P) | Punching out $1\frac{3}{4}"$ x 1 $1/8"$             |

\* Protection Ballistic Limit = 2863 fps

## Front Nose Plate

Cal. 30 AP M2 - Direct Frontal Attack

|     |      |       |  |
|-----|------|-------|--|
| 1   | Lost | —     | Disregard                                |
| 2   | Lost | —     | Disregard                                |
| 3   | 2857 | CP(P) | —  |
| 4   | 2747 | CP(P) | —  |
| 5   | 2566 | CP(P) | —  |
| 6   | Lost | —     | Disregard                                |
| 7   | 2394 | PP(P) | Cracked interior bracket $\frac{1}{4}$ " |
| 8   | 2353 | PP(P) | Slight bulge                             |
| 9   | Lost | —     | Disregard                                |
| *10 | 2466 | CP(P) | Large bulge - $3/8"$ horizontal crack    |
| *11 | 2423 | PP(P) | Large bulge - No cracking                |

\* Protection Ballistic Limit = 2445 fps

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**CONFIDENTIAL**Cal. 50 AP M2 - Direct Frontal Attack

| <u>Rd. No.</u> | <u>Velocity</u> | <u>CP(P)/PP(P)</u> | <u>Remarks</u>   |
|----------------|-----------------|--------------------|--|
| 1              | 2082            | CP(P)              | Exit diameter $7/16"$ x $7/16"$  |
| 2              | 1594            | PP(P)              | Slight bulge - No cracking   |
| *3             | 1733            | PP(P)              | Large bulge - $\frac{1}{2}"$ horizontal crack  |
| 4              | 1809            | CP(P)              | Large bulge - $\frac{1}{4}"$ x $\frac{1}{4}"$ opening<br>$5/8"$ horizontal crack - Pip |
| *5             | 1779            | CP(P)              | Large bulge - $1/8"$ x $1/8"$<br>opening - $\frac{1}{2}"$ horizontal crack             |

\* Protection Ballistic Limit = 1756 fps

Cal. 50 Ball M2 - Direct Frontal Attack

|    |      |       |   |
|----|------|-------|---|
| 1  | 2201 | CP(P) | Exit diameter $\frac{1}{2}"$ x $\frac{1}{2}"$ |
| 2  | 1788 | PP(P) | Large bulge - $\frac{1}{4}"$ horizontal crack |
| 3  | 1878 | CP(P) | Large bulge $3/4"$ horizontal crack           |
| *4 | 1802 | PP(P) | Large bulge $\frac{1}{2}"$ horizontal crack   |
| *5 | 1844 | CP(P) | Large bulge $5/8"$ horizontal crack           |

\* Protection Ballistic Limit = 1823 fps

Cal. 50 AP M2 -  $30^{\circ}$  Frontal Flank Attack

|    |      |       |   |
|----|------|-------|---|
| 1  | Lost | CP(P) | Large bulge - $5/8"$ horizontal crack   |
| 2  | Lost | CP(P) | Exit diameter $7/16"$ x $7/16"$ - $\frac{1}{2}"$ - $\frac{1}{2}"$ horizontal cracks |
| 3  | 2021 | PP(P) | Slight bulge  |
| *4 | 2093 | PP(P) | Slight bulge  |
| 5  | 2243 | CP(P) | Exit diameter $\frac{1}{2}"$ x $\frac{1}{2}"$                                       |
| 6  | 2175 | CP(P) | Exit diameter $\frac{1}{2}"$ x $\frac{1}{2}"$                                       |
| *7 | 2124 | CP(P) | Large bulge - $3/4"-5/8"$ horizontal crack  |

\* Protection Ballistic Limit = 2109 fps

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**CONFIDENTIAL**Cal. 50 AP M2 - 30° Frontal Flank Attack

| Rd. No. | Velocity | CP(P)/FP(P) | Remarks   |
|---------|----------|-------------|---|
| 1       | 2098     | PP(P)       | No bulge  |
| *2      | 2247     | PP(P)       | Large bulge 3/4" horizontal hairline crack  |
| 3       | 2319     | CP(P)       | Exit diameter $\frac{1}{2}$ " x $\frac{1}{2}$ " - Two $\frac{1}{2}$ " horizontal cracks |
| *4      | 2267     | CP(P)       | Exit diameter $\frac{1}{2}$ " x $\frac{1}{2}$ " - 3/4" horizontal crack                 |

\* Protection Ballistic Limit = 2257 fps

Cal. 50 AP M2 - 60° Frontal Flank Attack

|   |      |       |          |
|---|------|-------|----------|
| 1 | 2350 | PP(P) | No bulge |
| 2 | 2704 | PP(P) | No bulge |
| 3 | 2783 | PP(F) | No bulge |
| 4 | 2846 | PP(P) | No bulge |

\* No Protection Ballistic Limit Obtained - High Partial Penetration = 2846 fps

## Personnel Access Door in Ramp

Cal. 50 Fragment Simulator - 0° Obliquity

|   |      |       |                                    |
|---|------|-------|------------------------------------|
| 1 | 2703 | PP(P) | Large bulge - No cracking          |
| 2 | 2720 | PP(P) | Large bulge - Fine hair line crack |
| 3 | 2835 | PP(P) | Large bulge - No cracking          |
| 4 | 2891 | PP(P) | Large bulge - No cracking          |

\* No Protection Ballistic Limit Obtained - High Partial Penetration = 2891 fps

Cal. 50 Fragment Simulator - 45° Obliquity

|   |      |       |                            |
|---|------|-------|----------------------------|
| 1 | 2374 | PP(P) | Slight bulge - No cracking |
| 2 | 2472 | PP(P) | Slight bulge - No cracking |
| 3 | 2580 | PP(P) | Slight bulge - No cracking |

\* No Protection Ballistic Limit Obtained - High Partial Penetration = 2580 fps

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**CONFIDENTIAL**20-mm Fragment Simulator - 45° Obliquity

| Rd. No. | Velocity | CP(P)/PP(P) | Remarks                              |
|---------|----------|-------------|--------------------------------------|
| 1       | 2068     |             | Disregard                            |
| 2       | 2331     | CP(P)       | Exit diameter $1\frac{1}{4}$ " x 1"  |
| *3      | 2197     | CP(P)       | Exit diameter 1" x 1"                |
| 4       | 2085     | PP(P)       | Large bulge - $1\frac{1}{2}$ " crack |
| 5       | 2051     | PP(P)       | Medium bulge - No cracks             |
| 6       | 2094     | PP(P)       | Large bulge - No cracks              |
| *7      | 2135     | PP(P)       | Large bulge - $\frac{1}{2}$ " crack  |

\* Protection Ballistic Limit = 2166 fps

## RESISTANCE TO PENETRATION

T117

## Upper Hull Side Plate - Right Side

Cal. 50 AP M2 - 0° Obliquity

|    |      |       |                              |
|----|------|-------|------------------------------|
| 1  | 1413 | CP(P) | 1/8" x 1/8" opening on rear  |
| 2  | 1297 | PP(P) | Large bulge - pin hole light |
| 3  | 1338 |       | Disregard                    |
| 4  | 1296 | PP(P) | Large bulge - pin hole light |
| *5 | 1298 | PP(P) | Large bulge - pin hole light |
| *6 | 1344 | CP(P) | Large bulge - 1/8" opening   |

\* Protection Ballistic Limit = 1321 fps

Cal. 50 Ball M2 - 0° Obliquity

|     |      |       |  |
|-----|------|-------|--|
| 1   | 1499 | PP(P) | No bulge - no cracking                           |
| 2   | 2875 | CP(P) | Exit diameter 7/8" x 7/8"                        |
| 3   | 2302 | PP(P) | Medium bulge - no cracks                         |
| 4   | 2633 | CP(P) | Exit diameter 3/4" x 3/4"                        |
| *5  | 2504 | CP(P) | Exit diameter 5/8" x 5/8"                        |
| 6   | 1852 | PP(P) | Medium bulge - no cracking                       |
| 7   | 2064 | PP(P) | Large bulge - no cracking                        |
| 8   | 2004 | PP(P) | Large bulge - no cracking                        |
| 9   | 2173 | PP(P) | Large bulge - no cracking                        |
| 10  | 2508 | CP(P) | Punching out 5/8" x 5/8"                         |
| *11 | 2468 | PP(P) | Large bulge - no cracking - Projectile in plate. |

\* Protection Ballistic Limit = 2486 fps

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**CONFIDENTIAL**Cal. 30 AP M2 - 0° Obliquity

| Rd. No. | Velocity | CP(P)/PP(P) | Remarks  |
|---------|----------|-------------|--|
| 1       | 2055     | PP(P)       | Slight bulge - no cracking                     |
| 2       | 2588     | CP(P)       | Punching out $\frac{1}{4}$ " x $\frac{1}{4}$ " |
| 3       | 2319     | CP(P)       | Large bulge - pin hole opening                 |
| 4       | 2276     |             | Disregard                                      |
| 5       | 2248     | CP(P)       | Large bulge - pin hole opening                 |
| 6       | 2283     | CP(P)       | Large bulge - projectile nose through plate    |
| 7       | 2279     | CP(P)       | Large bulge - $1/16$ " x $1/16$ " opening      |
| 8       | 2135     | PP(P)       | Medium bulge - no cracking                     |
| 9       | 2266     | CP(P)       | Large bulge - $1/16$ " x $1/16$ " opening      |
| *10     | 2174     | PP(P)       | Medium bulge - no cracks                       |
| 11      | 2232     |             | Disregard                                      |
| *12     | 2235     | PP(P)       | Large bulge - fine hair cracking               |

\* Protection Ballistic Limit = 2205 fps .

Cal. 30 AP M2 - 45° Obliquity

|   |      |       |                            |
|---|------|-------|----------------------------|
| 1 | 3096 | PP(P) | Slight bulge - no cracking |
| 2 | 3280 | PP(P) | Slight bulge - no cracking |
| 3 | 3444 | PP(P) | Slight bulge - no cracking |

\* No Protection Ballistic Limit Obtained - High Partial Penetration = 3444 f.p.s.

Cal. 50 AP M2 - 45° Obliquity

|    |      |       |  |
|----|------|-------|--|
| 1  | 2001 | PP(P) | Slight bulge - no cracking             |
| 2  | 2857 | CP(P) | Punching out $5/8$ " x $3/8$ "         |
| 3  | 2365 | PP(P) | Slight bulge - no cracking             |
| 4  | 2639 | PP(P) | Large bulge - no cracking              |
| *5 | 2781 | PP(P) | Large bulge - no cracking              |
| *6 | 2829 | CP(P) | Punching out $\frac{1}{2}$ " x $3/8$ " |

\* Protection Ballistic Limit = 2805 fps

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**CONFIDENTIAL**20-mm Fragment Simulator - 45° Obliquity

| <u>Rd. No.</u> | <u>Velocity</u> | <u>CP(P)/PP(P)</u> | <u>Remarks</u>                           |
|----------------|-----------------|--------------------|--|
| 1              | 1870            | PP(P)              | Slight bulge - no cracks                 |
| 2              | 1969            | PP(P)              | Slight bulge - no cracks                 |
| 3              | 2076            | PP(P)              | Medium bulge - no cracks                 |
| 4              | 2191            | PP(P)              | Medium bulge - no cracks                 |
| 5              | 2334            | PP(P)              | Medium bulge - no cracks                 |
| 6              | Lost            | PP(P)              | Large bulge - $\frac{1}{2}$ " hair crack |
| 7              | 2585            | PP(P)              | Large bulge - no cracks                  |
| 8              | 2534            | PP(P)              | Slight bulge - no cracks                 |
| 9              | 2701            | PP(P)              | Large bulge - $\frac{3}{4}$ " face crack |
| 10             | 2869            | PP(P)              | Large bulge - no cracks                  |
| 11             | 2873            | PP(P)              | Large bulge - no cracks                  |

\* No Protection Ballistic Limit Obtained - High Partial  
Penetration = 2873 fps

## Personnel Access Door in Ramp

Cal. 50 Fragment Simulator - 0° Obliquity

|   |      |       |                            |
|---|------|-------|----------------------------|
| 1 | 2785 | PP(P) | Slight bulge - no cracking |
| 2 | 2909 | PP(P) | Slight bulge - no cracking |
| 3 | 2899 | PP(P) | Slight bulge - no cracking |
| 4 | 2933 | —     | Disregard                  |

\* No Protection Ballistic Limit Obtained - High Partial  
Penetration = 2909 fps

20-mm Fragment Simulator - 45° Obliquity

|    |      |       |                                 |
|----|------|-------|---------------------------------|
| 1  | 1953 | PP(P) | Large bulge - no cracking       |
| 2  | 2005 | PP(P) | 1" circular crack               |
| 3  | 2234 | PP(P) | Large bulge - no cracking       |
| *4 | 2349 | CP(P) | Punching out $7/8$ " x $7/16$ " |
| 5  | 2264 | PP(P) | Large bulge - no cracking       |
| *6 | 2274 | PP(P) | Large bulge - hair line crack   |

\* Protection Ballistic Limit = 2312 fps

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## APPENDIX E

## Detailed Test Data

## Phase IV

## T117 - PERSONNEL ACCESS DOOR

## Projectile: Cal. 30 Ball M2 Service

| Rd.<br>No. | Condition<br>of Attack | Location<br>of Impacts  | Penetration | Results<br>Bullet Splash |
|------------|------------------------|---|-------------|--------------------------|
|            |                        |   | Penetration | Results<br>Bullet Splash |
| 1          | Direct Rear            | Hit in the opening between the personnel access door and the rear ramp.<br>Disregarded. | PP          | None                     |
| 2          | Direct Rear            | Hit in the opening between the personnel access door and the rear ramp.                 | -           | -                        |
| 3          | Direct Rear            | Hit in the opening between the personnel access door and the rear ramp.<br>Disregarded  | PP          | None                     |
| 4          | Direct Rear            | Hit in the opening between the personnel access door and the rear ramp.<br>Disregarded  | -           | -                        |
| 5          | Direct Rear            | Hit in the opening between the personnel access door and the rear ramp.<br>Disregarded. | PP          | None                     |
| 6          | Direct Rear            | Disregarded.  | -           | -                        |
| 7          | Direct Rear            | Disregarded.  | -           | -                        |
| 8          | Direct Rear            | Hit in the opening between the personnel access door and the rear ramp.                 | PP          | None                     |
| 9          | Direct Rear            | Hit in the opening between the personnel access door and the rear ramp.                 | PP          | None                     |
| 10         | 45° Rear Flank         | Disregarded   | -           | -                        |
| 11         | 45° Rear Flank         | Disregarded   | -           | -                        |
| 12         | 45° Rear Flank         | Hit in the opening between the personnel access door and the rear ramp.                 | PP          | None                     |
| 13         | 45° Rear Flank         | Hit in the opening between the personnel access door and the rear ramp.                 | PP          | None                     |
| 14         | 45° Rear Flank         | Hit in the opening between the personnel access door and the rear ramp.                 | PP          | None                     |
| 15         | 45° Rear Flank         | Hit in the opening between the personnel access door and the rear ramp.                 | PP          | None                     |

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Projectile: Cal. 50 Ball MP Service

| Rd. No. | Condition of Attack | Location of Impacts   | Penetration (A) | Results Bullet Splash |
|---------|---------------------|---|-----------------|-----------------------|
| 16      | Direct Rear         | Disregarded.  | -               | -                     |
| 17      | Direct Rear         | Hit in the opening between the personnel access door and the rear ramp. | CP              | None                  |
| 18      | Direct Rear         | Hit in the opening between the personnel access door and the rear ramp. | CP              | None                  |
| 19      | 45° Rear Flank      | Disregarded.  | -               | -                     |
| 20      | 45° Rear Flank      | Hit in the opening between the personnel access door and the rear ramp. | PP              | None                  |
| 21      | 45° Rear Flank      | Hit in the opening between the personnel access door and the rear ramp. | PP              | None                  |
| 22      | 45° Rear Flank      | Hit in the opening between the personnel access door and the rear ramp. | PP              | None                  |
| 23      | 45° Rear Flank      | Hit in the opening between the personnel access door and the rear ramp. | PP              | None                  |

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THE RESISTANCE TO BULLET SPLASH FROM SMALL ARMS FIRE

ROUND-BY-ROUND-FIRING RESULTS

T113-ENGINE INSPECTION DOOR

Projectile: Cal. 30 Ball M2 Service

| Rd.<br>No. | Condition<br>of Attack | Location<br>of Impacts  | Penetration<br>(A) | Results<br>Bullet Splash |
|------------|------------------------|---|--------------------|--------------------------|
|            |                        |   | Penetration<br>(A) | Results<br>Bullet Splash |
| 1          | 45° Obliquity          | Disregarded.  | -                  | -                        |
| 2          | 45° Obliquity          | Hit in the opening between the engine access door and engine inspection door.                   | PP                 | None                     |
| 3          | 45° Obliquity          | Disregarded.  | -                  | -                        |
| 4          | 45° Obliquity          | Hit in the opening in the right side between the engine access door and engine inspection door. | PP                 | None                     |
| 5          | 45° Obliquity          | Disregarded.  | -                  | -                        |
| 6          | 45° Obliquity          | Disregarded.  | -                  | -                        |
| 7          | 45° Obliquity          | Hit in the opening between the engine access door and the engine inspection door.               | PP                 | None                     |
| 8          | 45° Obliquity          | Hit in the opening between the engine access door and the engine inspection door.               | PP                 | None                     |
| 9          | 0° Obliquity           | Disregarded.  | -                  | -                        |
| 10         | 0° Obliquity           | Disregarded.  | -                  | -                        |
| 11         | 0° Obliquity           | Hit in the opening between the engine access door and the engine inspection door.               | PP                 | None                     |
| 12         | 0° Obliquity           | Hit in the opening between the engine access door and the engine inspection door.               | PP                 | None                     |
| 13         | 0° Obliquity           | Hit in the opening between the engine access door and the engine inspection door.               | PP                 | None                     |

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Projectile: Cal. 50 Ball M2 Service

| Rd. No. | Condition of Attack | Location of Impacts | Penetration (A)   | Results Bullet Splash |
|---------|---------------------|---------------------|---|-----------------------|
| 14      | 45°                 | Oblliquity          | Disregarded.  | -                     |
| 15      | 45°                 | Oblliquity          | Hit in the opening between the engine access door and the engine inspection door. | PP                    |
| 16      | 45°                 | Oblliquity          | Hit in the opening between the engine access door and the engine inspection door. | PP                    |
| 17      | 45°                 | Oblliquity          | Hit in the opening between the engine access door and the engine inspection door. | PP                    |
| 18      | 45°                 | Oblliquity          | Hit in the opening between the engine access door and the engine inspection door. | PP                    |
| 19      | 0°                  | Oblliquity          | Disregarded.  | PP                    |
| 20      | 0°                  | Oblliquity          | Hit in the opening between the engine access door and the engine inspection door. | CP                    |
| 21      | 0°                  | Oblliquity          | Hit in the opening between the engine access door and the engine inspection door. | CP                    |

T113 - ENGINE ACCESS DOOR

Projectile: Cal. 30 Ball M2 Service

|   |     |            |   |    |      |
|---|-----|------------|---|----|------|
| 1 | 45° | Oblliquity | Hit in the opening between the engine access door and the sloped nose plate.    | PP | None |
| 2 | 45° | Oblliquity | Hit in the opening between the engine access door and the sloped nose plate.    | PP | None |
| 3 | 45° | Oblliquity | Hit in the opening between the engine access door and in the sloped nose plate. | PP | None |

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Projectile: Cal. 50 Ball M2 Service

| <u>Rd No.</u> | <u>Condition of Attack</u> | <u>Location of Impacts</u>   | <u>Penetration (A)</u> | <u>Results Bullet Splash</u> |
|---------------|----------------------------|--|------------------------|------------------------------|
| 4             | 45° Obliquity              | Disregarded.   | -                      | -                            |
| 5             | 45° Obliquity              | Hit in the crack between the engine access door and the sloped nose plate. | PP                     | None                         |
| 6             | 45° Obliquity              | Hit in the crack between the engine access door and the sloped nose plate. | PP                     | None                         |
| 7             | 45° Obliquity              | Disregarded  | -                      | -                            |
| 8             | 45° Obliquity              | Disregarded  | -                      | -                            |
| 9             | 45° Obliquity              | Hit in the crack between the engine access door and the sloped nose plate. | PP                     | None                         |

TL13-CARGO HATCH

Projectile: Cal. 30 Ball M2 Service

|    |              |  |    |      |
|----|--------------|--|----|------|
| 1  | 0° Obliquity | Disregarded.   | -  | -    |
| 2  | 0° Obliquity | Hit in the opening between the hatch cover and the hatch ring. | CP | None |
| 3  | 0° Obliquity | Hit in the opening between the hatch cover and the hatch ring. | CP | None |
| 4  | 0° Obliquity | Disregarded.   | -  | -    |
| 5  | 0° Obliquity | Disregarded.   | -  | -    |
| 6  | 0° Obliquity | Disregarded.   | -  | -    |
| 7  | 0° Obliquity | Hit in the opening between the hatch cover and the hatch ring. | CP | None |
| 8  | 0° Obliquity | Hit in the opening between the hatch cover and the hatch ring. | CP | None |
| 9  | 0° Obliquity | Disregarded.   | -  | -    |
| 10 | 0° Obliquity | Disregarded.   | -  | -    |
| 11 | 0° Obliquity | Disregarded.   | -  | -    |
| 12 | 0° Obliquity | Hit in the opening between the hatch cover and the hatch ring. | CP | None |

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1113-COM'DR CUPOLA

Projectile: Cal. 30 Ball M2

| <u>Rd.<br/>No.</u> | <u>Striking<br/>Vel. f/s</u> | <u>Condition<br/>of Attack</u> | <u>Location<br/>of Impacts</u>                             | <u>Penetration<br/>(A)</u> | <u>Results<br/>Bullet Splash</u> |
|--------------------|------------------------------|--------------------------------|--|----------------------------|----------------------------------|
| 1                  | 1960                         | 0° Obliquity                   | Hit in the opening between the hatch cover and hatch ring. | CP                         | None                             |
| 2                  | 1958                         | 0° Obliquity                   | Hit in the opening between the hatch cover and hatch ring. | CP                         | None                             |
| 3                  | 1975                         | 0° Obliquity                   | Hit in the opening between the hatch cover and hatch ring. | CP                         | None                             |
| 4                  | 1970                         | 0° Obliquity                   | Hit in the opening between the hatch cover and hatch ring. | CP                         | None                             |

Projectile: Cal. 30 Ball M2 Service

| <u>Rd.<br/>No.</u> | <u>Condition<br/>of Attack</u> | <u>Location<br/>of Impacts</u>                             | <u>Penetration<br/>(A)</u> | <u>Results<br/>Bullet Splash</u> |
|--------------------|--------------------------------|--|----------------------------|----------------------------------|
| 5                  | 15° Obliquity                  | Disregarded  | -                          | -                                |
| 6                  | 15° Obliquity                  | Disregarded  | -                          | -                                |
| 7                  | 15° Obliquity                  | Hit in the opening between the hatch cover and hatch ring. | PP                         | None                             |
| 8                  | 15° Obliquity                  | Hit in the opening between the hatch cover and hatch ring. | PP                         | None                             |
| 9                  | 15° Obliquity                  | Disregarded  | -                          | -                                |
| 10                 | 15° Obliquity                  | Hit in the opening between the hatch cover and hatch ring. | PP                         | None                             |
| 11                 | 15° Obliquity                  | Hit in the opening between the hatch cover and hatch ring. | PP                         | None                             |
| 12                 | 15° Obliquity                  | Hit in the opening between the hatch cover and hatch ring. | PP                         | None                             |
| 13                 | 30° Obliquity                  | Hit in the opening between the hatch cover and hatch ring. | PP                         | None                             |

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| Rd.<br>No. | Condition<br>of Attack | Location<br>of Impacts   | Penetration<br>(A) |    | Results<br>Bullet Splash |
|------------|------------------------|--|--------------------|----|--------------------------|
|            |                        |  | PP                 | PP |                          |
| 14         | 30° Obliquity          | Hit in the opening between the hatch cover and hatch ring.                 | PP                 | PP | None                     |
| 15         | 30° Obliquity          | Hit in the opening between the hatch cover and hatch ring.                 | PP                 | PP | None                     |
| 16         | 30° Obliquity          | Hit in the opening between the hatch cover and hatch ring.                 | PP                 | PP | None                     |
| 17         | 45° Obliquity          | Disregarded.   | -                  | -  | -                        |
| 18         | 45° Obliquity          | Hit in the opening between the hatch cover and hatch ring.<br>Disregarded. | PP                 | -  | None                     |
| 19         | 45° Obliquity          | Disregarded.   | PP                 | -  | -                        |
| 20         | 45° Obliquity          | Hit in the opening between the hatch cover and hatch ring.                 | PP                 | PP | None                     |
| 21         | 45° Obliquity          | Hit in the opening between the hatch cover and hatch ring.                 | PP                 | PP | None                     |

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